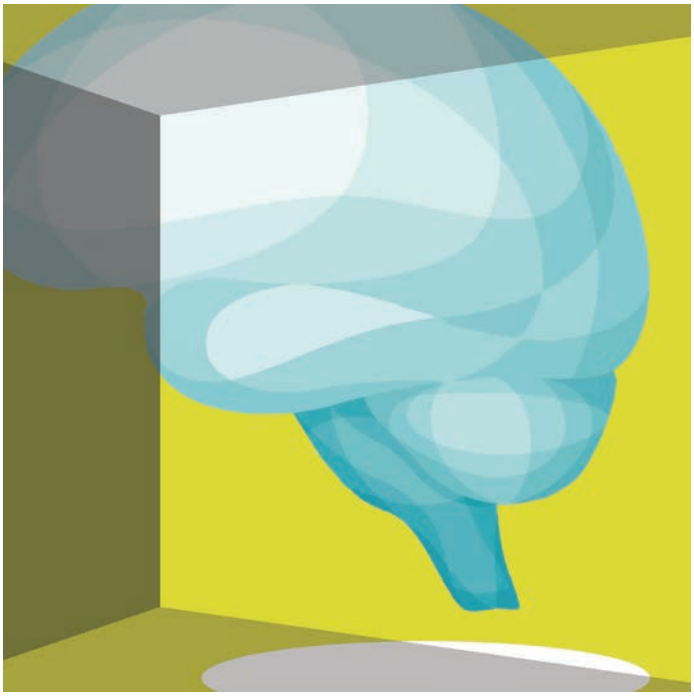
TRANSFORMING THE WORLD THROUGH

SCIENCE

2nd Edition



National Science Foundation

Message from the Director

The recently released *Science and Engineering Indicators 2018*, the National Science Board's biennial report to Congress, confirmed that research and development (R&D) remains a major driver of innovation, and the United States remains the largest R&D-performing country.

As the only federal agency that invests in fundamental, basic research across all non-medical fields of science and engineering, NSF has played a leading role in helping the U.S. secure and maintain its competitive edge globally. Ninety-three percent of NSF's annual budget supports groundbreaking basic research, STEM education and development of the STEM workforce. This support is a critical source of federal funding for fields like computer science, biology, the social sciences, mathematics and the physical sciences.

Advances in science and engineering ensure the U.S. economy stays strong, that Americans remain safe and secure, and that the nation continues to advance the frontiers of knowledge on scales ranging from the subatomic to the cosmic. NSF's support for innovative STEM education keeps the nation's workforce competitive and ready to take on future challenges. NSF strives to provide every aspiring scientist and engineer access to the resources they need to prepare for a career in science or engineering.

At NSF, we say that our investments in early stage research are where discoveries begin. This book highlights where some of those discoveries lead and how our lives are transformed by NSF's sustained support of fundamental research. At the same time, we are keeping an eye on the future with our "10 Big Ideas for Future NSF Investments." NSF is uniquely positioned to identify and catalyze research in these frontier areas.

Holding true to our mission, NSF is ensuring that the nation remains a major global influence in science and technology, and is always on the forefront of discovery and innovation.

France A. Córdova

Director, National Science Foundation

NSF HISTORY

BASIC RESEARCH: A NATIONAL RESOURCE

On October 4, 1957, the Soviet Union launched Sputnik I, an event that served as a stark example of another nation's growing scientific and technological capabilities, and which elicited deep anxieties over American national security.

Just days after Sputnik's launch, Alan T. Waterman, the first director of the National Science Foundation (NSF), delivered a report to President Dwight D. Eisenhower titled "Basic Research: A National Resource." The report surveyed the nation's current basic research activities and firmly asserted its importance, describing basic research as "an activity that is so indispensable to the Nation that the Federal Government cannot avoid responsibility for its encouragement and support." The report signaled the agency's leading role in supporting science research and education and demonstrated its readiness to respond to a national crisis. Recognizing NSF's leadership, Congress responded by more than tripling the agency's budget for the next fiscal year.

While Sputnik — described by Waterman as a "scientific Pearl Harbor" — brought public attention to science and engineering research, the federal government's investment in basic research began during World War II. During the war, impressive innovations such as radar, penicillin and atomic weaponry resulted from federally supported basic research. As the war drew to a close, President Franklin D. Roosevelt looked to the prominent scientist Vannevar Bush to develop a plan for continuing federal support for basic research into peacetime. In response, Bush issued his now famous report, "Science: The Endless Frontier," which set in motion the creation of NSF. In his report, Bush explained, "A nation which depends upon others for its new basic scientific knowledge will be slow in its industrial progress and weak in its competitive position in world trade."

On May 10, 1950, President Harry S. Truman signed the National Science Foundation Act, creating NSF, whose mission is "to promote the progress of science; to advance the

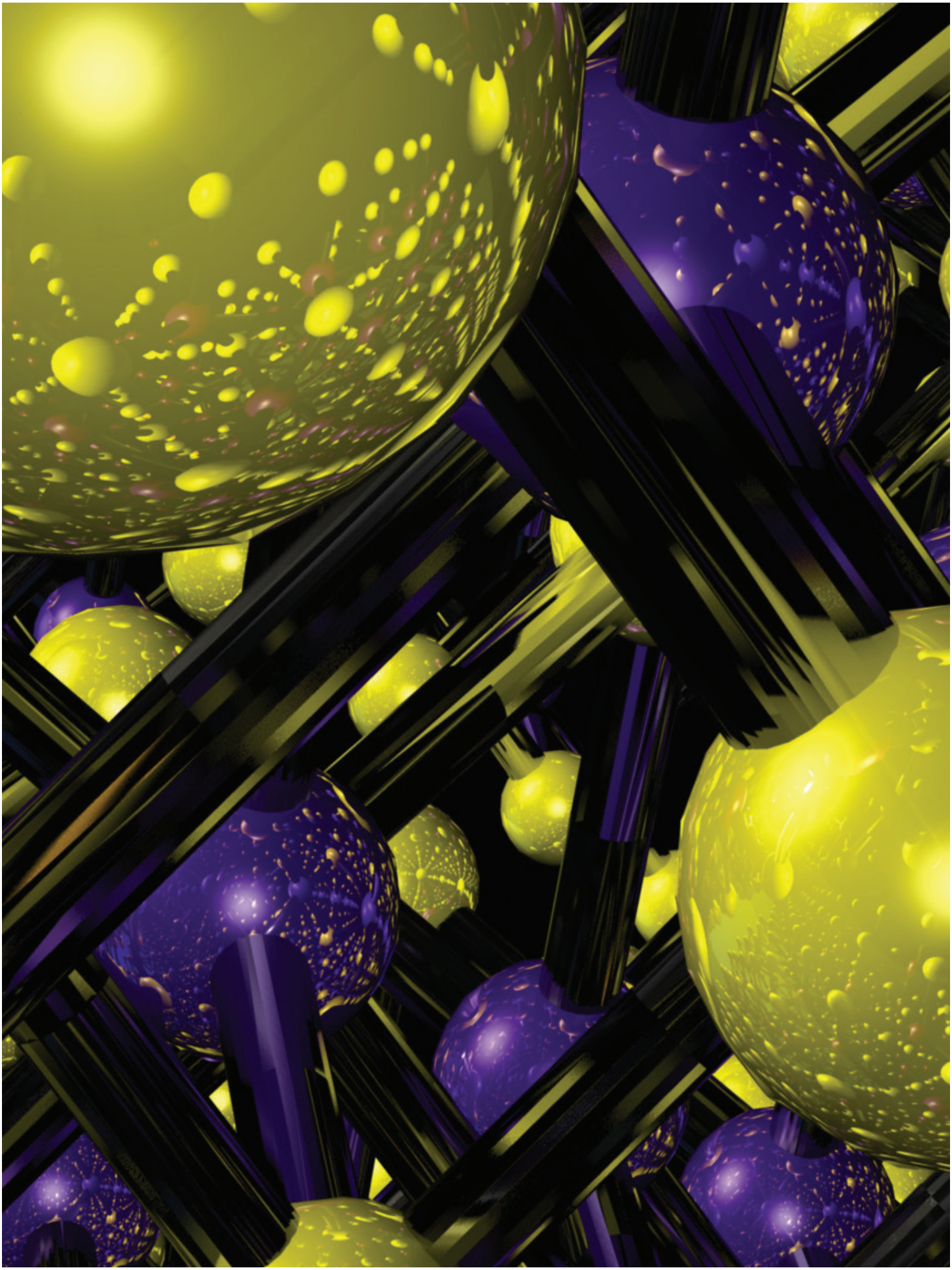
national health, prosperity and welfare; to secure the national defense." It is the only agency dedicated to supporting basic research and education across all fields of science and engineering. But what is basic research, and what value does it add to society? Waterman defined basic research as "that type of research which is directed toward [the] increase of knowledge in science. It is research where the primary aim of the investigator is a fuller knowledge or understanding of the subject under study, rather than a practical application thereof."

> *"to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense"*

The broad range of fundamental research supported by NSF since its creation serves as a critical resource for the nation, whether in times of peace or conflict. When disasters strike, innovations derived from NSF-funded research provide solutions and assistance. Such research also forms the cornerstone of American economic strength and global leadership.

Though it often takes many years for knowledge gained through basic research to reach an application, the societal benefits that have emerged over the decades leave little doubt that investments in basic research are, as Bush described, the "key to our security as a nation, to our better health, to more jobs, to a higher standard of living and to our cultural progress."

This beautiful mural, located at NSF's headquarters in Alexandria, Virginia, is a visual depiction of NSF's impact on the nation through support of nearly seven decades of scientific discovery and innovation.



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EXECUTIVE SUMMARY

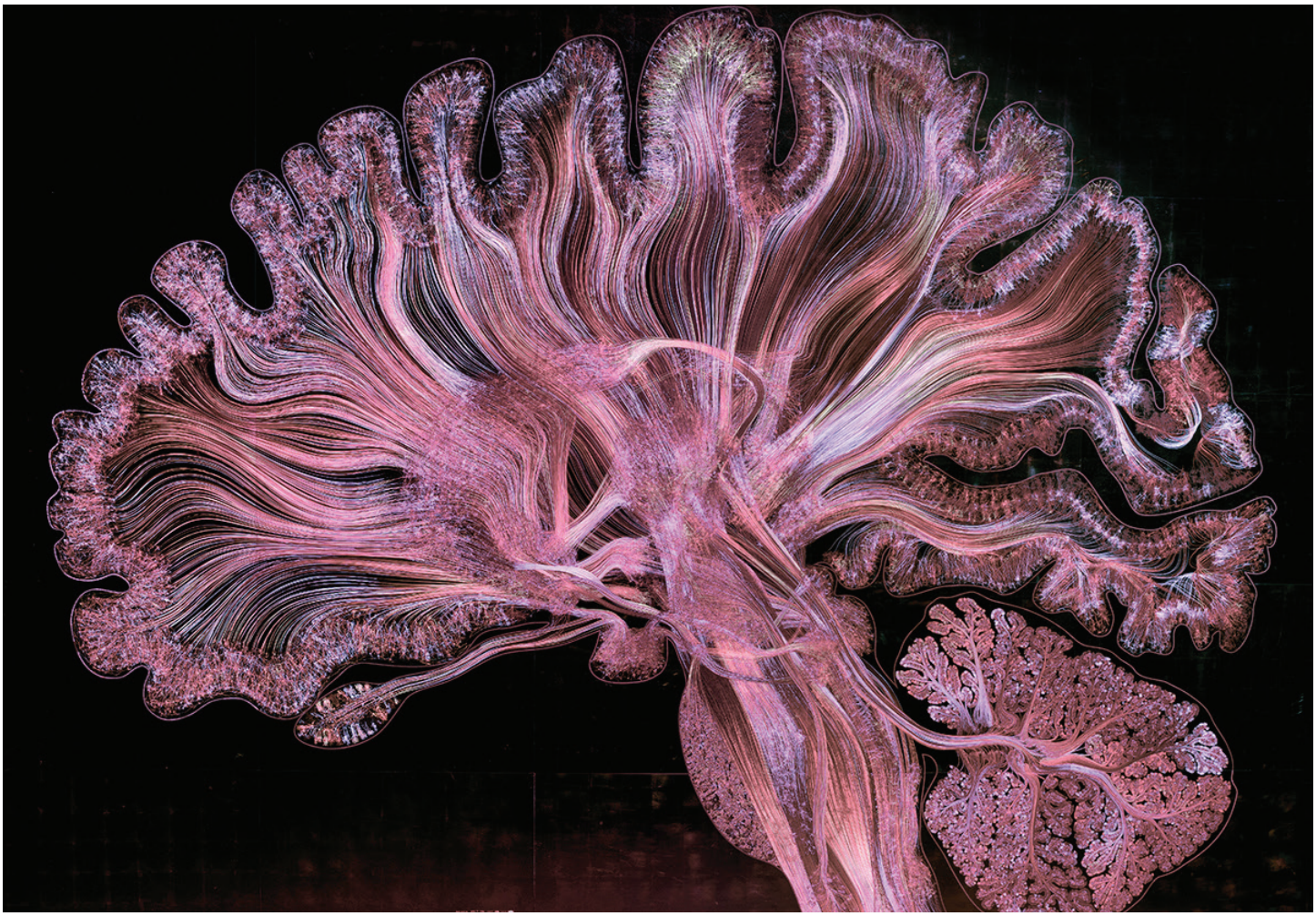
Basic research pushes the boundaries of what is possible and creates a deeper understanding of the world around us. The National Science Foundation (NSF) fuels that painstaking pursuit for answers across all science and engineering (S&E) fields.

Though not primarily focused on practical applications, basic research nevertheless leads to the breakthroughs that result in new industries, new technologies and an improved quality of life. This book is a snapshot of impacts that come from NSF-funded investments. It does not capture the entire scope of research that NSF supports, nor is it a complete record of the many inventions, products, services and industries that have come from NSF-funded research. Instead, it is a glimpse of how science addresses societal challenges.

Beginning on page 9, these impacts are laid out in four main sections focused on the economy, national security, advancing knowledge and health and well-being. These four themes align with NSF's core mission: "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense."

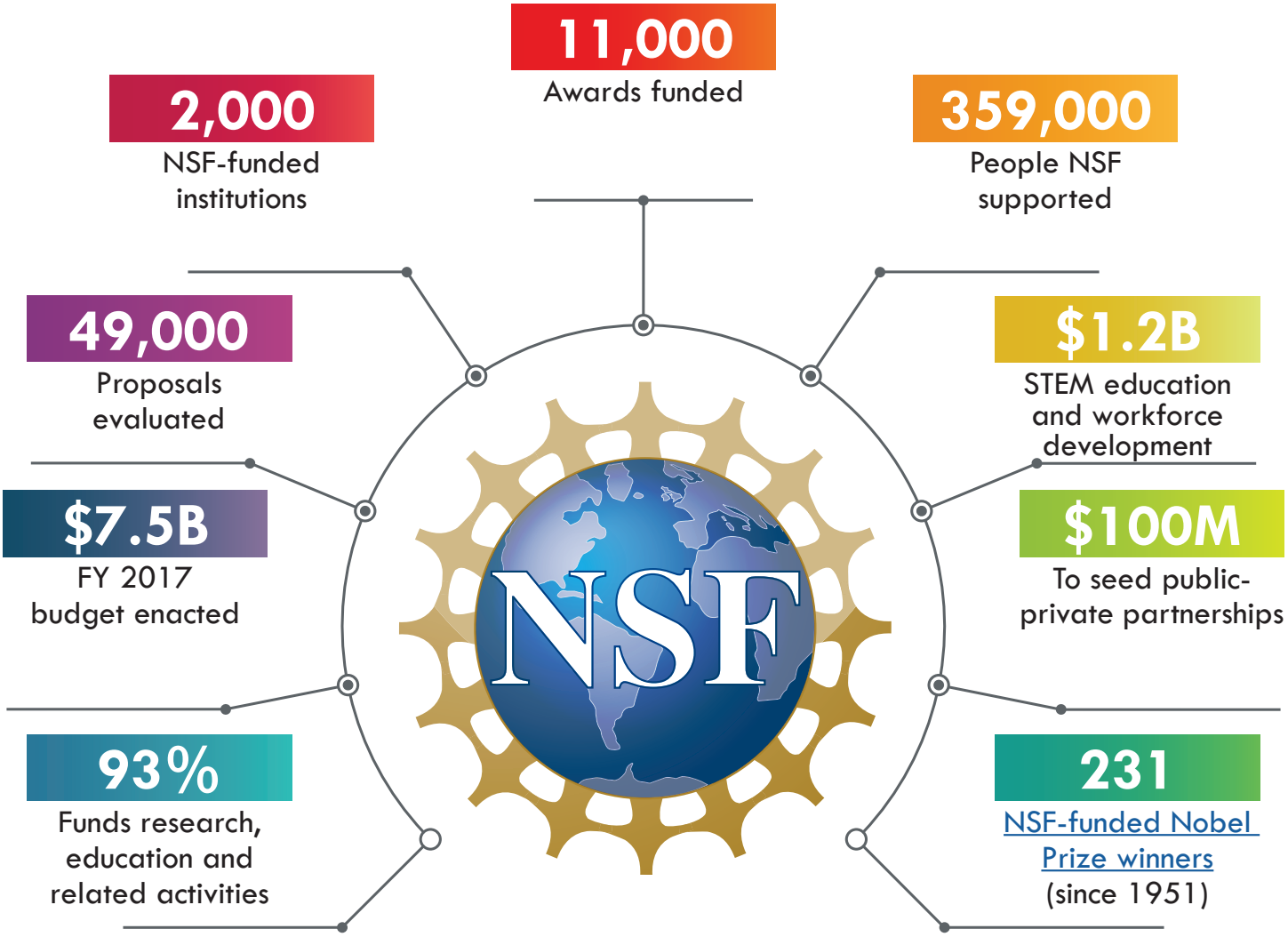
The following pages, starting with "NSF by the Numbers" on page 2, give a flavor of what makes the agency unique. Pages 33-36 lay out NSF's "10 Big Ideas for Future NSF Investments" — bold research agendas that engage societal challenges and aim to catalyze new breakthroughs from the S&E community.

This book will hopefully give the reader a better understanding of and appreciation for the investments in basic research that transform the world around us.



NSF BY THE NUMBERS

The figures below help demonstrate NSF's unique role in promoting the progress of science. The agency reviews tens of thousands of research proposals each year and invests in research with the greatest potential for advancing the frontiers of knowledge. All proposals undergo NSF's rigorous merit review process, recognized as the gold standard for evaluating proposals in a competitive environment. The agency's support for fundamental, basic research and science, technology, engineering and mathematics (STEM) education extends to all 50 states, tangibly impacting local and regional economies while strengthening the nation's economy, security, well-being and global competitiveness.



Numbers shown are based on fiscal year 2017 activities.

DIRECTORATES AND OFFICES

BIOLOGICAL SCIENCES

Basic research supported by NSF's Biological Sciences Directorate (BIO) seeks to understand how humans and other animals, plants and a host of microorganisms persist

and interact with one another, and how they respond and adapt to a variety of environmental conditions. BIO-supported researchers identify the basic rules that determine how life on Earth has thrived and diversified. Their work leads to new ways to prevent and treat diseases, improve agricultural practices, and conserve natural resources.

The field of biology, transformed by technology and the incorporation of "Big Data," stands at the threshold of new breakthroughs and engages researchers from all areas of S&E. BIO invests in the infrastructure, tools and theories needed to advance the biological sciences and ensure the U.S. remains at the forefront of discovery. Outcomes from BIO-funded research transform human health, food security, conservation of biodiversity and more, making biology an engine for innovation in the 21st century.

COMPUTER AND INFORMATION SCIENCE AND ENGINEERING

Advances in computing, communication and information technologies have rapidly and profoundly transformed lives, addressed national priorities, and driven U.S. economic competitiveness. From the internet and assistive robotics to driverless cars and countless machine-learning applications, fundamental research supported by NSF's Computer and Information Science and Engineering Directorate (CISE) has created the scientific and engineering foundations for myriad breakthrough technologies over the last several decades.

CISE-supported activities continue to address grand challenges. For example, exploring the integration of physical infrastructure such as transportation networks and the energy grid with "cyber" capabilities will yield

new jobs and contribute to economic growth in the nation's cities and communities. Efforts to maximize the benefits of advanced cyberinfrastructure, including the design, development and deployment of high-performance computing resources, will accelerate discovery in all fields of S&E. Additionally, building the knowledge base and capacity for computer science education will expand its access to all students across the nation, providing them with the skills essential for success in the new era of data and computation.

EDUCATION AND HUMAN RESOURCES

To sustain U.S. leadership and excellence in STEM, and to meet the high-technology workforce needs of today and tomorrow, the U.S. must maintain a vigorous investment in its STEM human capital.

NSF's Education and Human Resources Directorate (EHR) supports STEM education and education research from

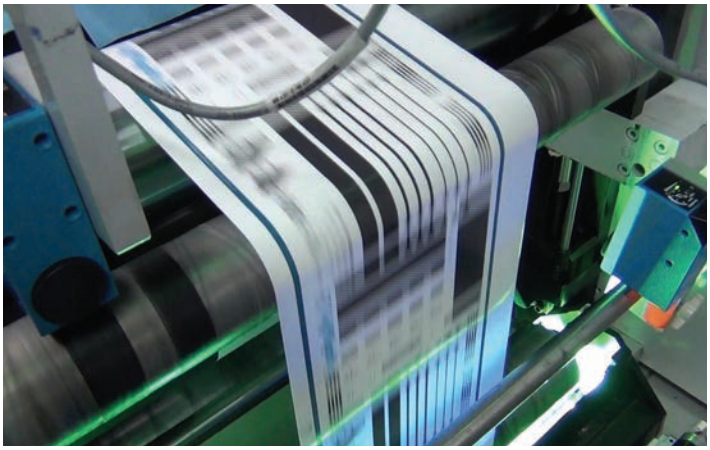
early childhood learning to doctoral work and beyond. EHR funds evidence-based innovations in teaching practices, instructional tools and programs that advance STEM education and prepare the next generation of STEM professionals.

EHR further works to ensure that STEM education and career opportunities are available to all Americans, including groups that have been traditionally underrepresented in STEM.

The goal of EHR investments is to expand the STEM education research knowledge base and develop tools and practices that inform efforts toward improvement. The longer-term impact of these investments is a science-literate U.S. public and a workforce that is diverse, innovative and prepared to lead in S&E.

ENGINEERING

Engineering is essential for a future where people thrive. Today, engineers are making this future a reality through research in advanced manufacturing, healthcare, sustainability, infrastructure and more. Engineering researchers create new knowledge, concepts and designs that become technological breakthroughs and solve real-world problems. They innovate for clean water, the electric grid, agriculture and other national challenges.



They enable economic opportunities in areas such as 3-D printing and secure communications. Engineers improve people's lives with smart transportation, prosthetic devices, faster computers and everything in between.

NSF's Engineering Directorate (ENG) supports discovery across all these areas and more. To speed innovations to the market, ENG spurs entrepreneurship, small business growth and industry collaboration. The directorate also advances engineering education and builds an inclusive engineering workforce capable of solving 21st-century challenges. Investments in engineering are critical building blocks for the nation's future prosperity, security and global competitiveness.

GEOSCIENCES

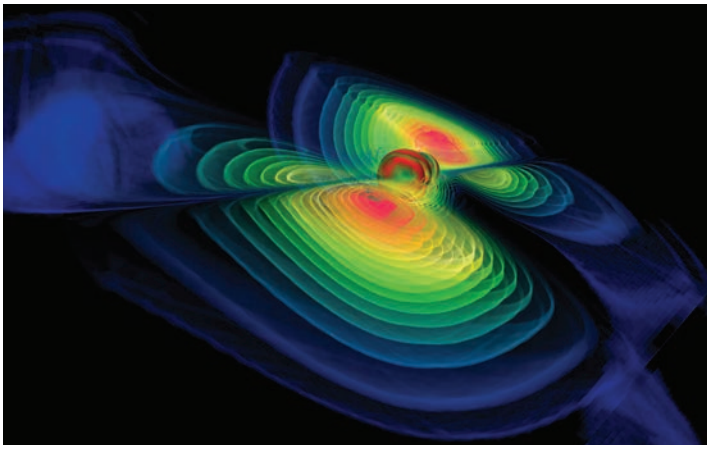
The Geosciences Directorate (GEO) funds research that advances knowledge of natural processes of the land, oceans and atmosphere, and at the poles. Lives are saved and property preserved through better prediction and understanding of earthquakes, tornados, hurricanes, tsunamis, drought and solar storms. GEO supports the laboratories, vessels, aircraft, equipment

and other infrastructure and logistics for this research. The directorate also has a vibrant education and outreach program to help build a future workforce that includes weather forecasters, educators, biologists, astrophysicists, hydrologists, social and economic scientists, oceanographers, glaciologists, seismologists, and engineers and scientists in the oil, gas, petroleum and mining industries.

Strong partnerships extend the reach and impact of GEO-funded research. GEO is a key player in the Ocean Research Priority Plan and the Global Seismic Network. NSF helps coordinate research planning in the Arctic, manages the U.S. presence in Antarctica on behalf of the nation and is a vital member of the U.S. Delegations to the Antarctic Treaty System.

MATHEMATICAL AND PHYSICAL SCIENCES

The Mathematical and Physical Sciences Directorate (MPS) supports fundamental research in astronomy, chemistry, materials, the mathematical sciences and



physics. This research excites the imagination and changes lives, expanding the frontiers of scientific knowledge and providing a foundation that supports economic growth, societal well-being and national security.

The investigations funded by MPS encompass a vast range of topics, from research on the smallest particles to the largest galaxies, from number theory to quantum information science, and from biomaterials to chemical catalysis. Its award portfolio extends from large facilities, such as telescopes, to research grants for individual scientists.

The discoveries from this research advance the understanding of the world around us and provide the foundation needed to create technologies to improve the quality of life. MPS-funded research propels the nation's investments in a host of important areas such as sustainable energy and food supplies, instrumentation and sensors, new materials and threat detection.

SOCIAL, BEHAVIORAL AND ECONOMIC SCIENCES

Nearly every major challenge the U.S faces — from protecting the nation from natural disasters and terrorism to helping children learn — requires understanding the causes and consequences of people's behavior. People shape and are shaped by the social, political, economic and environmental forces that surround them.

NSF's Social, Behavioral and Economic Sciences Directorate (SBE) supports rigorous research that examines this constellation of factors to generate a deeper understanding of human behavior in all its complexity across space and time. SBE-funded scientists study the relationship between the brain and behavior, including how the brain produces cognition, language, emotion and action. They also study how people interact with each other in families and organizations, and how these interactions can produce stability and cooperation or conflict.

Ultimately, the findings from SBE-funded research provide insights that improve health and well-being, strengthen the economy, enhance national security and reinforce U.S. leadership in scientific discovery and innovation.

OFFICE OF INTEGRATIVE ACTIVITIES

Transformative research and education frequently crosses boundaries, requiring the integration of multiple theories, methods, data and modes of thinking. NSF's Office of Integrative Activities (OIA) addresses grand challenges in cross-cutting areas through a portfolio of programs and activities that enhances the development of new technologies and products, strengthens the nation's safety and security, and advances U.S. leadership in global research and development (R&D).

Science and Technology Centers conduct world-class R&D through partnerships among academic institutions, national laboratories and private-public entities. The

Established Program to Stimulate Competitive Research (EPSCoR) bolsters S&E capacity through research infrastructure improvements and STEM workforce development in eligible states and territories. OIA's Major Research Instrumentation Program increases access to multi-user S&E instrumentation for cutting-edge research and research training. Convergence, one of NSF's 10 Big Ideas, augments a more traditional transdisciplinary approach to research by framing challenging research questions at inception, and fostering the collaborations needed for successful inquiry.

OFFICE OF INTERNATIONAL SCIENCE AND ENGINEERING

The Office of International Science and Engineering (OISE) is the NSF focal point for international S&E activities. OISE promotes an integrated, foundation-wide international engagement strategy and manages internationally focused programs that prepare U.S. students to become members of the global STEM workforce. The office focuses on international activities to promote innovation among the U.S. research community through access to international knowledge, infrastructure and capabilities.

OISE emphasizes three activities: 1) promoting the development of a globally competent U.S. workforce; 2) facilitating and supporting international partnerships; and 3) seeking opportunities for the U.S. to shape the global S&E agenda.

NSF IN ACTION

NSF shares the critical importance of basic research in multiple ways, including news stories, films, online activities, student competitions and Capitol Hill events. These efforts reach a wide audience, from elementary school students to policymakers.

"The Antarctica Series," produced by *The New York Times* with NSF support, spotlighted the challenges of conducting research at the South Pole.

NSF Director France Córdova and members of the House Science Committee traveled to Greenland to visit field camps, including Summit Station, in operation atop the Greenland Ice Sheet since 1988.

"If the horseless carriage was the main attraction of the Washington Auto Show a century ago, what eye-catching innovations will take center stage 96 years from now? At NSF, we have our eye on the horizon."

- NSF Director France Córdova at the 2017 Washington Auto Show

NSF senior leadership took part in a number of events in 2017, including the Washington Auto Show in Washington, D.C., the G7 Science Ministerial in Italy, the SOAR Summit in Kentucky, the World Science Festival in New York and the World Economic Forum in Switzerland.

The winners of the 2017 Nobel Prizes in physics, chemistry, physiology or medicine, and economics all received NSF funding during their careers.

The 2017 "Great American Eclipse" offered scientists a unique opportunity to observe key features of the sun, such as the mysterious corona. The public also contributed to eclipse research through the NSF-funded Citizen CATE experiment and other citizen science projects.

High school students from Virginia, Georgia and New Mexico who won NSF's "Generation Nano: Small Science, Superheroes" competition, visited Capitol Hill and attended D.C.'s comic convention, Awesome Con, where they exhibited their nano-inspired superheroes. At Awesome Con, NSF also showcased research on everything from solar eclipses to dinosaur fossils in Antarctica.

"Before, I was interested in studying physics, just to learn about the universe. That kind of intellectual exploration is nice and it's fun, but after CCIC, I was much more focused on taking that knowledge and making a difference in people's lives too. Now I'm minoring in innovation and entrepreneurship and trying to turn several of my ideas into businesses."

- Dallas Elleman, Community College Innovation Challenge (CCIC) finalist

Elleman was formerly a cable technician. He now studies engineering physics with a concentration in robotics at the University of Tulsa.

Thirty scientists participated in a two-month expedition to the "lost" continent of Zealandia aboard the scientific drillship *JOIDES Resolution*.

NSF and the Coalition for National Science Funding highlighted the tangible impacts of federally funded basic research at "The Arc of Science: Research to Results" on Capitol Hill.

Community college student teams from across the U.S. competed in the third annual Community College Innovation Challenge (CCIC), applying creative scientific and engineering solutions to real-world problems.

FUELING THE U.S. ECONOMY

"to advance the national prosperity"

NSF's enduring commitment to fund high-risk, high-reward ideas strengthens the U.S. economy by producing the discoveries that lead to emerging industries and jobs. NSF also upholds America's competitive edge by funding research that leads to new tools and technologies, and education efforts that train and prepare a 21st century workforce.

Support of nanotechnology, 3-D printing and micro-electromechanical systems, for example, helped transform modern manufacturing. Fundamental physics and mathematics research contributed to advanced medical imaging and new cancer treatments. The agency's support for basic economics research resulted in the reconfiguration of U.S. and global monetary systems, and earned 55 NSF grantees the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel.

In addition, NSF helps researchers and small businesses translate scientific innovations and knowledge into commercial products and services through programs like the Small Business Innovation Research program (SBIR) and NSF Innovation Corps (I-Corps™).

Included here are a few examples of NSF's impact on industry, small businesses and America's workforce.

BOLSTERING INDUSTRY

NSF's basic research investments lead to new industries that provide everything from a faster internet to stronger crops, disease detection and natural resource exploration. NSF-funded innovators also deliver new products and services to the marketplace.

FASTER INTERNET

In the internet's early days, NSF-funded researchers at the Massachusetts Institute of Technology (MIT) developed algorithms to quickly deliver content via a geographically distributed network of servers, reducing internet congestion. The work launched a multi-billion-dollar industry, and two members of the research team founded Akamai Technologies.

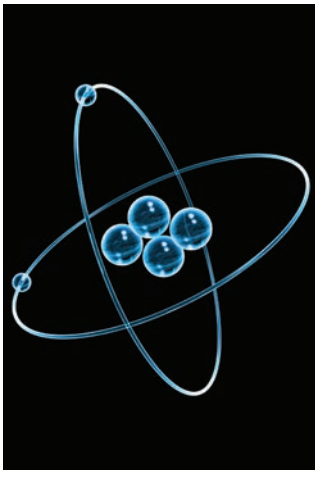
As one MIT researcher noted in a 2000 final report about NSF's funding of this work: "Our work on replication and load balancing has led to the establishment of a startup company, Akamai Technologies, that uses our techniques in the real world. Besides having attracted over $40 million in venture funding, Akamai already has clients such as Yahoo and Apple paying to get improved performance in their web servers." Today, Akamai is valued at $10 billion and routes 15-30 percent of the world's internet traffic.

LAUNCHING TECH INDUSTRY TITANS

In 1979, NSF awarded a grant to Machine Intelligence Corporation to improve how computers process language. That company, whose ideas were inspired in part by NSF-funded basic research at the University of Texas, later became Symantec, whose market value is about $19 billion.

In the late 1980s, NSF small business grants helped a startup develop a new type of chip for wireless communications. This chip ultimately ended up in most cellphones and other smart technologies. The company, Qualcomm, now has a market value of $76 billion.

In the mid-1990s, Google co-founders Sergey Brin, an NSF Graduate Research Fellow, and Larry Page, whose work was supported through an NSF Digital Library Initiative grant, created the page-ranking algorithm that would become the basis for their groundbreaking search engine.



BOOSTING HELIUM PRODUCTION

Helium is a scarce but essential natural resource with applications in a variety of areas including medical imaging, clean energy production and threat detection. Through a 2007 NSF-funded award to extract underground argon for dark matter research, a new source of helium was discovered in Cortez, Colorado. The helium comes from carbon dioxide (CO_2) gas flowing through a CO_2 extraction plant owned by Kinder Morgan Inc., one of the largest energy infrastructure companies in North America. The discovery encouraged Air Products Corporation, a worldwide leader in industrial gas production, to build a $134 million helium production facility in Doe Canyon. This facility is expected to provide an equivalent of at least 15 percent of the supply generated by the National Helium Reservoir in Amarillo, Texas.

DID YOU KNOW? John B. Goodenough's energy storage materials research was essential to development of the lithium ion battery, which powers nearly every mobile device and most all-electric and hybrid automobiles. Since 1974, NSF supported Goodenough with 22 grants.

SUPPORTING SMALL BUSINESSES

Powered by NSF, America's Seed Fund awards nearly $200 million annually to startups and small businesses through its SBIR program. These ventures provide jobs and offer new ways to solve diverse challenges.

BRINGING ENERGY, INTERNET TO RURAL COMMUNITIES

The lack of affordable energy and limited access to high-speed internet inhibits growth in many rural communities. Altaeros Energies builds small, autonomously controlled airships tethered half a kilometer above the ground to meet the energy and internet needs of these communities. The airborne infrastructure platform serves wind turbines and cell towers equally well. At that height, winds are stronger and more consistent than on the ground, enabling a less expensive system to capture large amounts of electricity. The elevation, in turn, allows providers to reach an area equivalent to 30 conventional towers.

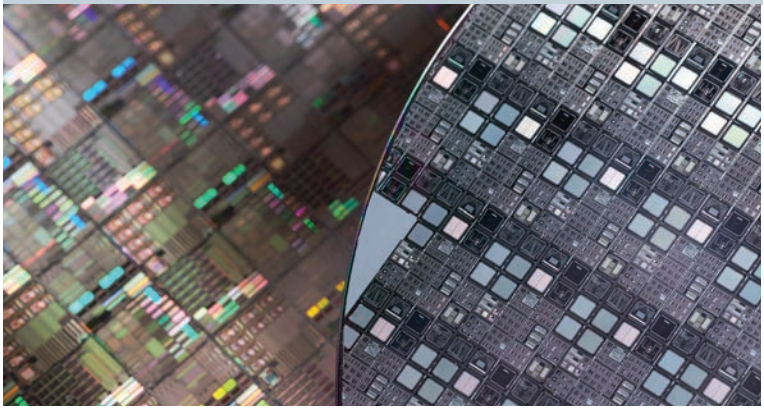
NSF support is helping Altaeros improve system design and engineering. Once implemented, Altaeros' tethered airships aim to provide energy and communications to rural and isolated communities, including those recovering from disaster.

CULTIVATING SMART FARM TOOLS

Weeding for commercial farms is costly. In addition, reducing or eliminating the use of herbicides on crops is an important goal in the fast-growing organic farming sector. With support from NSF's SBIR program, Blue River Technology developed tractor-mounted robotic systems to rapidly identify and kill weeds, while leaving valuable crops untouched. The company's machinery identifies unwanted plants by species and location amid labor-intensive crops like lettuce and cotton. Its platforms constantly learn from observations in the field and from a large database, where weeds are identified by comparing them to tens of thousands of images. In 2017, John Deere acquired Blue River for $305 million.

NEXT-GENERATION COMPUTER CHIPS

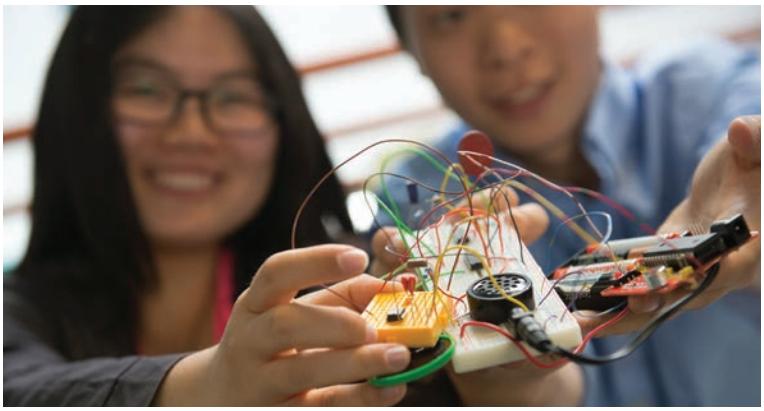
To keep pace with demands for more power, better efficiency and lower cost, computer chip manufacturers developed a new fabrication method — extreme ultraviolet lithography – a promising technique to fabricate new feature-packed chips. But producing those chips required a new chip template. Inpria, a small company founded on NSF-funded materials research, has pioneered a tin oxide template that produces features so fine that using it rather than previous templates is like changing from a fat marker to a fine-point pen to print chip features. In 2016, *Chemical & Engineering News* named Inpria one of "10 startups to watch." The company has secured $23.5 million in financing from leading players across the semiconductor manufacturing ecosystem.



DID YOU KNOW? NSF investments in basic physics research led to an advanced laser technology now used in LASIK vision correction. IntraLase was founded by NSF-supported researchers who later received NSF SBIR awards to develop the technology. In 2007, Advanced Medical Optics acquired IntraLase for more than $800 million.

PREPARING A FUTURE-FOCUSED WORKFORCE

Many future jobs will be high-tech or require at least some STEM training and knowledge. To remain competitive, NSF monitors the nation's S&E enterprise and invests in programs that train tomorrow's scientists, engineers and workforce.



STATE OF THE U.S. S&E WORKFORCE

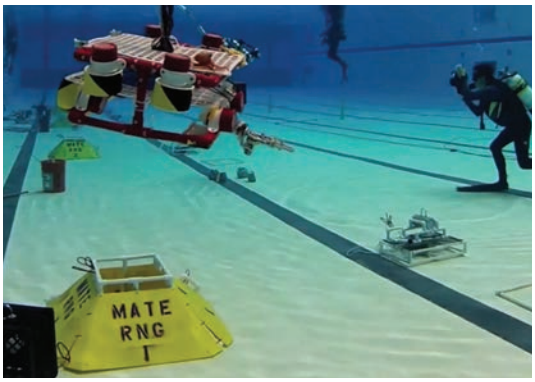
In the U.S., the S&E workforce has grown faster over time than the overall workforce and represents more than 4 percent of all U.S. jobs, according to NSF's National Center for Science and Engineering Statistics. Furthermore, workers with S&E training are working in occupations not formally classified as S&E jobs, suggesting the application of S&E knowledge and skills is needed across the U.S. economy.

At the same time, some countries are outpacing the U.S. in the percentage of bachelor's degrees earned in S&E (49 percent in China, 33 percent in the U.S.). A number of NSF programs are working to increase access to and interest in STEM at all education levels.

CYBERCORPS STUDENTS SOLVING CRIME

Students at the University of Tulsa enrolled in the NSF-supported CyberCorps® Scholarships for Service (SFS) program helped the Tulsa Police Department solve a 2003 triple homicide case by extracting emails and instant messages from the hard drive of a suspect's computer. Additionally, Tulsa CyberCorps SFS students assisted U.S. Secret Service agents in extracting evidence from damaged cellphones and GPS devices, and one student made a major breakthrough in a presidential threat case.

The CyberCorps SFS program awards scholarships to students at institutions with strong cybersecurity education programs. Graduates then serve for a time in cybersecurity-related positions at the NSA, CIA, FBI and other areas of government. Since 2001, there have been about 3,250 scholarship recipients.



STUDENTS RUN MILLION-DOLLAR DRONE BUSINESS

Students at California's Monterey Peninsula College run a million-dollar business manufacturing and selling remotely operated underwater vehicles (ROVs) to K-12 schools. The business is an outgrowth of the community college's Marine Advanced Technology Education (MATE) center, which has received funding through NSF's Advanced Technology Education program since 1997.

Through coursework and hands-on experience, MATE prepares students for marine occupations, including marine forecasters, ocean instrument technicians and ROV technicians. MATE also helped 19 of its partner colleges develop courses and programs in marine technology, with more than 9,000 students enrolled in marine technology programs at affiliated colleges in the last 14 years. The center hosts an international ROV competition that challenges students to design and build ROVs that take on missions related to the ocean workplace.

DID YOU KNOW? NSF's I-Corps provides hands-on entrepreneurship training to academic researchers. In 2016, women accounted for 19 percent of I-Corps participants.

"Acquiring investor capital for seed stage R&D is very difficult and the investors that do participate in such early financings look to external sources and experts to validate the technology and approach. Our NSF award was, in fact, that source of validation and within two weeks of having received our SBIR Phase I award, we closed our seed round. NSF was instrumental in getting our company off the ground."

-Rob Nordsell, co-founder and CEO, Lumenari Inc.

Lumenari was founded in Silicon Valley with support from NSF and currently operates in Kentucky. Lumenari's technology makes LED lights 20 to 40 percent brighter per unit of input power, which could strip 50 terawatt hours off the grid annually by 2030.

ENHANCING THE NATION'S SECURITY

"to secure the national defense"

Within 24 hours of the September 11 terrorist attacks, NSF-funded researchers arrived at Ground Zero with shoebox-sized robots to help locate survivors, to study how building structures failed, and to analyze the response to the attack. Their work would improve future search-and-rescue efforts, inform the design of next-generation buildings, and determine best practices for crisis communications and response procedures.

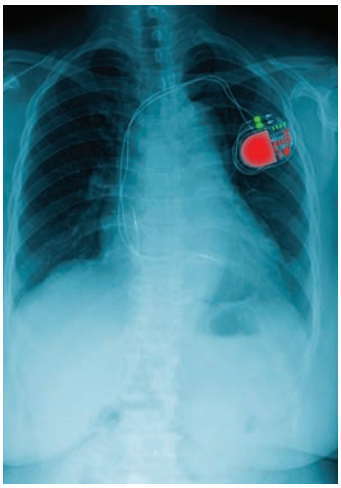
The nation's scientists and engineers have responded similarly to other catastrophes, from hurricanes and oil spills to cyberattacks. What they learn helps experts better protect communities and prepare for future events, and reinforces the nation's strength and resiliency.

NSF-funded research is often linked to applications that improve national preparedness and security, such as tools for detecting explosives, earthquake-resistant water pipelines and GPS devices used in navigation and defense mapping.

Included here are a few examples of NSF-funded research that are helping protect many of the nation's devices, systems and natural resources.

PROTECTING AGAINST CYBERCRIME

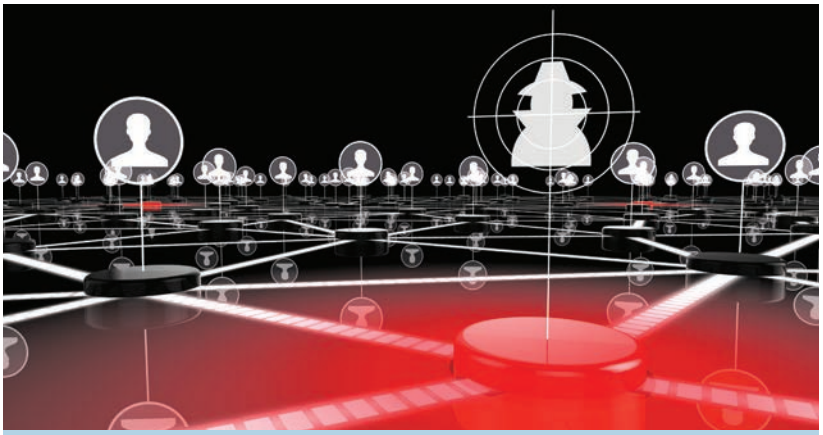
In a technology-dependent world, the interconnected systems that enhance U.S. productivity and global leadership also make the nation more vulnerable to attack. NSF-funded researchers are working to better understand and secure these systems.



TACKLING CYBERSECURITY IN HEALTHCARE

Wireless, implanted medical devices are pervasive in modern medical care. While they offer conveniences for doctors and patients and often improve patient outcomes, their technology poses security and privacy risks. NSF-funded computer scientists from the University of Massachusetts Amherst and the University of Michigan showed that it was possible for hackers to steal personal information from an implanted device and cause its malfunction. Incidents of ransomware at hospitals also demonstrated how these devices, especially when running on older software, could give hackers access to the broader health caresystem.

In 2013, two of the NSF-funded scientists developed a technology, PowerGuard, to spot malware on medical devices without interrupting patient care. Their company, Virta Labs, also helps healthcare providers solve cybersecurity problems in clinical settings.



STOPPING HACKERS, PROTECTING BUSINESSES

An NSF-funded researcher who received more than a decade of support for research on web-based malware developed new tools to identify and counteract malware. The researcher helped launch a company, StopTheHacker, whose artificial intelligence (AI) and machine learning technology provided website security for numerous entities including multinational companies and small businesses. When business websites are infected by malware, the result can lead to service disruptions, loss of productivity and damage to the brand and reputation of a business. StopTheHacker, which received support through NSF's SBIR program, provided software to businesses that used AI to identify and remove malware on their websites, protecting them and their customers. In 2014, CloudFlare, a web performance and security company valued at $1 billion, bought StopTheHacker.

PATCHING ANDROID VULNERABILITIES

In May 2017, NSF-funded computer scientists uncovered vulnerabilities in the Android operating system that would allow attackers to view information on a user's phone. The vulnerability occurs when the device's owner activates a legitimate app that requests permission to overlay a feature, such as a chat window, on the phone's screen. When enabled, this feature — the "cloak" — lets a hacker superimpose a fake window on top of the mobile user's window without their knowledge. The second app — the "dagger" — takes information captured by the hacker's "fake" window and conveys it to the real app beneath, giving the appearance that everything is normal. The scientists alerted Google and worked with the company to implement a fix. A patch for the problem was released in early September 2017.

DID YOU KNOW? The NSF-funded Stampede2 supercomputer helped first responders navigate areas flooded by hurricanes Harvey and Irma. Computer models showed where the water was, its likely depth and possible ways to reach flooded areas.

ENSURING SAFETY AT HOME AND ABROAD

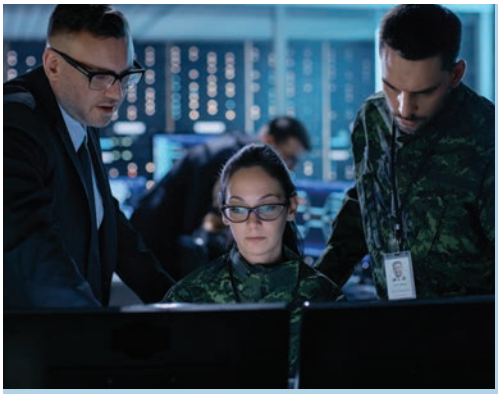
Police and border patrol officers, military planners and others tasked with keeping Americans safe at home and abroad are often equipped with technologies and knowledge that have grown out of NSF-funded research.

PREDICTING CRIME TO PREVENT IT

NSF-funded anthropologists and mathematicians at the University of California, Los Angeles, developed a mathematical model that combines historical crime data, bus routes, business locations, weather and other factors to produce a series of 500-by-500 foot areas called "prediction boxes" that identify where crime is likely to occur. The Los Angeles Police Department (LAPD) found that twice as much crime occurred in these model-generated areas as in similar areas selected by trained analysts. Police officers who used the boxes reduced actual crime in target areas compared to officers whose patrols relied on standard methods to guide them. Today, the LAPD and more than 50 other police departments around the world use these boxes as a routine part of their effort to keep communities and police officers safe.

THREAT DETECTION AT U.S. PORTS

After the attack on New York's Twin Towers, the 9/11 Commission recommended screening all cargo containers entering the U.S. Inspecting 12 million cargo containers annually presented a challenge, however. Existing X-ray technology is expensive, produces ionizing radiation and requires trained operators to review every scan. However, a new approach called the Multi-Mode Passive Detection System (MMPDS) provides rapid, in-line scanning of cargo for both security threats and illegal shipments. The system is completely automated and produces no radiation. The MMPDS detector technology is based in part on NSF-funded particle physics research that was originally developed to find and track subatomic particles for nuclear and high-energy physics experiments. The technology, used in Freeport, Bahamas, will soon be deployed in Singapore and the U.S.



WARNING SYSTEM AIDS U.S. MILITARY, POLICYMAKERS

American defense contractor Lockheed Martin used findings from years of NSF-funded research to develop the Integrated Crisis Early Warning System (ICEWS), now the Worldwide-Integrated Crisis Early Warning System, to help military planners and policymakers monitor and forecast regional and international crises. The core technology of the warning system integrates different techniques and conflict modeling approaches developed by a number of NSF-funded researchers, including one that automatically codes and parses digital news reports to generate political event data — the first of its kind.

ICEWS provides valuable intelligence to the U.S. military and policymakers, such as which countries or regions are likely to become more or less stable over a given time period and what U.S. response would likely mitigate a crisis.

DID YOU KNOW? An NSF-funded bioengineer and Army Reserve lieutenant colonel studies spider silk fibers to build lighter, stronger bulletproof vests, while an NSF-funded small business is developing a biopolymer, sprayable foam that can minimize blood loss on the battlefield.

PREPARING FOR FUTURE CHALLENGES

Good planning helps mitigate disasters and protect lives. The new tools and knowledge that grow out of NSF-funded research help society prepare for future challenges, such as food and water shortages and dangerous storms.

MANAGING WATER RESOURCES

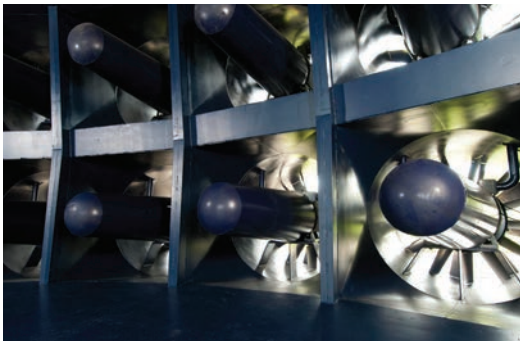
The Decision Center for a Desert City, a Decision Making Under Uncertainty (DMUU) center funded by NSF at Arizona State University, developed WaterSim, a visualization tool used by water utility managers in Phoenix and other desert cities in the Colorado River basin to inform water management decisions.

WaterSim takes data — population growth, climate, water supply and demand — compiled by different stakeholders and rolls them into one model to show how the different variables interact. Users change the variables and run different scenarios to better understand how factors, such as drought or population growth, will affect the system. Water managers, policymakers, educators and others use WaterSim to visualize complex data and estimate water supply and demand for cities like Phoenix.

NEXT-GENERATION FARMING

NSF-funded researchers at the University of Nebraska-Lincoln (UNL) developed a wireless network of underground sensors to give farmers real-time data on soil moisture, soil composition and other conditions. The sensors automate and enhance decision-making around irrigation by helping farmers know precisely when and how much to irrigate their fields. The research team founded Wildsense LLC to develop the product and secured a licensing agreement with NUtech Ventures, which commercializes UNL research.

NSF-funded researchers are also using cutting-edge genomic tools to develop new plant varieties that use nitrogen — a main component of fertilizer that often goes straight into groundwater — more efficiently. Researchers have identified the gene networks that process nitrogen and are exploring ways to increase crop yield using less nitrogen by modifying the plants' genes.



HIGH-TECH TOOLS, FACILITIES PROTECT LIFE AND LIMB

In 2017, natural disasters devastated islands, coastal towns and major metropolitan areas. Often, findings from NSF-funded research around a disaster site inform everything from the construction of more resilient infrastructure to more accurate warnings. Research from the NSF-funded Wall of Wind (WoW) facility at Florida International University, whose twelve, 6-foot-tall fans can simulate Category 5 hurricanes, altered the 2010 Florida building code to decrease the likelihood of sheared roofs and rooftop equipment during hurricanes.

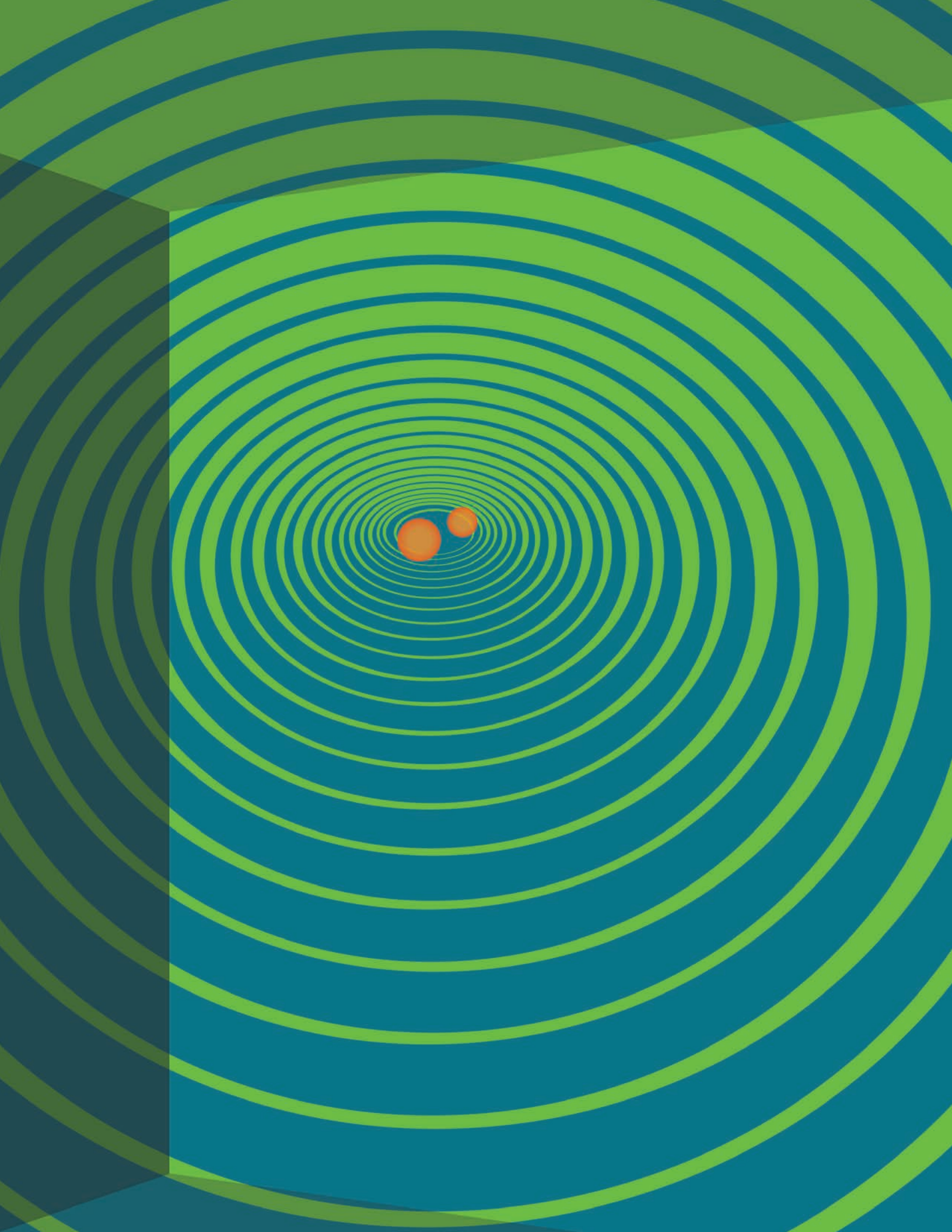
At the University of Oklahoma's Advanced Radar Research Center, researchers developed a radar simulator to help forecasters and meteorologists spot tornadic debris on radar. Flying debris is the main threat to people when tornadoes strike, yet identifying it on current weather radars has been difficult.

DID YOU KNOW? IcePod is an airborne sensor that collects data from flights in the polar regions and helps scientists understand how the Greenland and Antarctic ice sheets are changing. IcePod is a unique collaboration between NSF, researchers and the U.S. military.

"On a daily basis, the program creates a 12-hour map that predicts where the next crime will occur in an area. It's a very focused approach to crime fighting and we can do it with fewer officers in a more efficient and meaningful way. I would say it's pretty amazing."

- Captain Dominic Choi, LAPD, Pacific Division

The LAPD uses "prediction boxes" to reduce crime, in some cases by 25-30 percent. NSF-funded researchers created the prediction box model.



ADVANCING KNOWLEDGE

"to promote the progress of science"

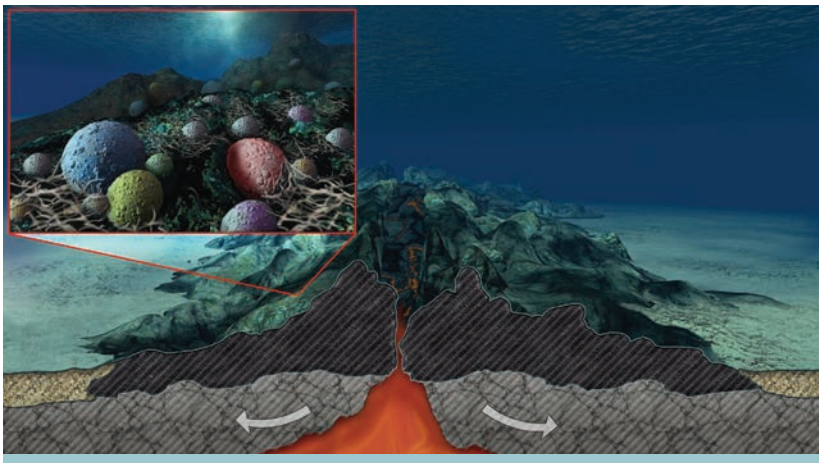
The U.S. basic research enterprise built by NSF is envied around the globe. At its core are the bold ideas from scientists and engineers eager to understand how the world works and how to make it better. They pursue fields from archaeology and astronomy to neuroscience and nanotechnology. Their discoveries underpin the nation's prosperity, security, technical expertise and well-being.

The path to discovery requires world-class instruments and facilities, such as telescopes, laboratories and research vessels, and education and training programs aimed at attracting individuals from every sector and group in society. These efforts are enhanced through partnerships at all levels from individuals to institutions and all sectors, including academia, government and industry, both domestic and international.

NSF will continue its mission to support men and women with a desire to illuminate the unknown, ensuring a pipeline of people and ideas ready to solve the pressing challenges facing the nation and the world.

EXPLORING NEW HORIZONS

With NSF funding, researchers can pursue various lines of inquiry and develop the tools needed to better understand the world and ourselves on multiple scales from atoms to outer space.



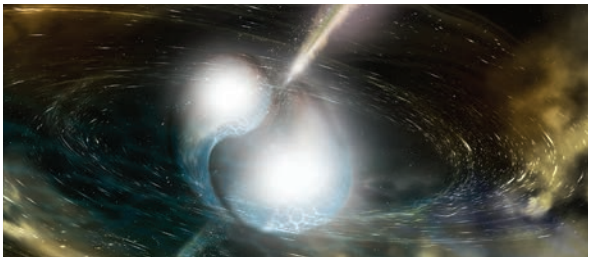
EXPLORING THE OCEAN FLOOR AND BEYOND

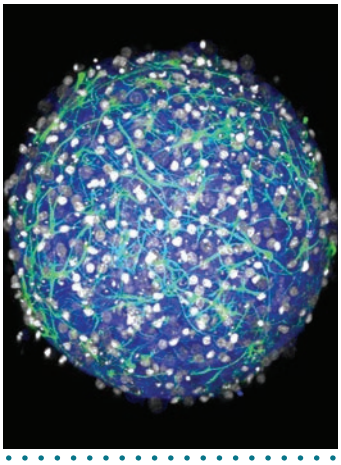
At the Center for Dark Energy Biosphere Investigation (C-DEBI), researchers use advanced tools and infrastructure to study life under the ocean floor. They sample organisms, sediments and rocks from the South Pacific to the Mid-Atlantic Ridge and the East Pacific Rise. Their gear includes specialized technologies like sensor arrays, deep-sea submersibles, scientific drilling ships, ROVs and autonomous deep-sea laboratories.

Recent analyses by C-DEBI teams suggest that deep-sea microbes play an important role in some of the Earth's most basic geochemical processes such as petroleum degradation and methane cycling. Other findings reveal marine sediments are the second largest water reservoir on the planet after the ocean. This work continues NSF's more than 60-year tradition of ocean exploration.

LIGO-VIRGO DETECT MERGING NEUTRON STARS

In August 2017, for the first time ever, scientists observed both gravitational waves and light resulting from a binary neutron star merger 130 million light-years away. NSF's Laser Interferometer Gravitational-Wave Observatory (LIGO), the Virgo detector in Europe and some 70 ground- and space-based observatories detected the cosmic event, which was much closer than previously detected black hole mergers. The detection also revealed one source of heavy elements such as gold and platinum, clarifying a decades-long mystery about their origins. This combination of technologies and international collaboration provides unprecedented opportunities to expand understanding of new cosmic phenomena and determine the physics of stars as scientists chart their death spiral.





MINI-BRAINS ADVANCE HUMAN BRAIN RESEARCH

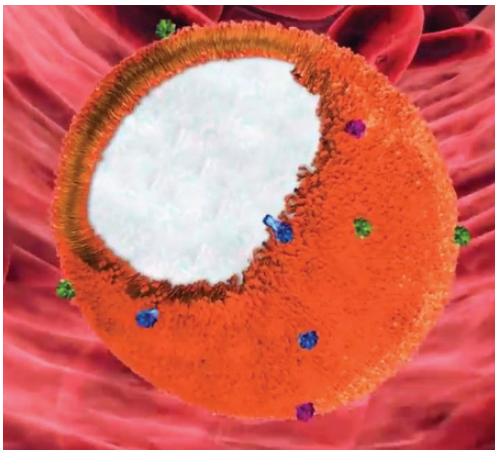
The human brain contains about 86 billion nerve cells, billions of nerve fibers and trillions of connections between them. To probe this complex network, in 2015, NSF-funded researchers developed a 3-D model of about 8,000 nerve and supporting cells, described as a "mini-brain." Unable to think but electrically active, the mini-brain offers an inexpensive, easy-to-make model to study nerve cell networks and the impact of drugs on nerve tissue or nerve tissue transplants. The mini-brain costs about a quarter to grow.

In 2017, the researchers discovered that the mini-brains produce networks of capillaries, a critical feature needed to study brain conditions, injuries and diseases such as stroke, concussions and Alzheimer's. Researchers can now alter tissue conditions or introduce drugs to observe tissue responses.

DID YOU KNOW? Integrated Digitized Biocollections (iDigBio) at the University of Florida and Florida State University is digitizing the nation's biological and paleontological collections. iDigBio's data and images are an online resource for the research community, government agencies, students, educators and the public.

THE BIG IMPACT OF SMALL SCIENCE

Atoms and proteins are the building blocks of matter and living organisms, and these ultrasmall particles often behave in unusual ways. Harnessing their unique properties can lead to new approaches in computing, drug therapy and high-speed communications.



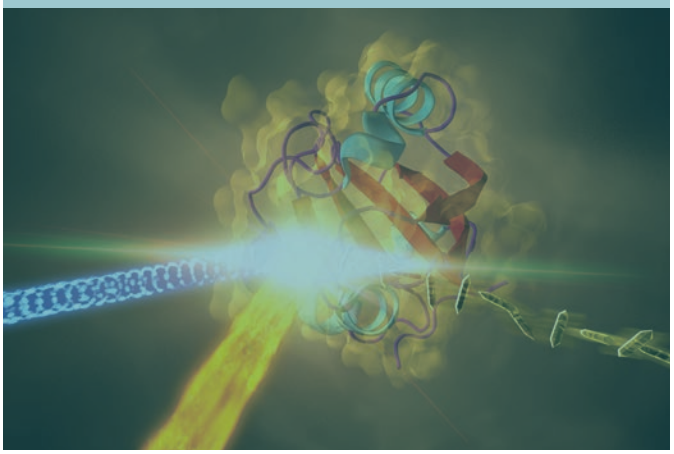
BUILDING THE NANOTECHNOLOGY FIELD

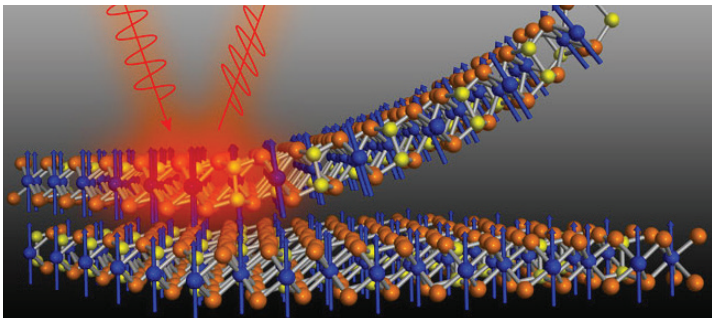
By 2025, the global nanotechnology market could reach nearly $174 billion. Beginning with the nanoparticle research initiative in 1991, NSF has invested nearly $10 billion in nanoscale S&E. NSF supports nano-oriented centers and networks across the country to discover the fundamental mechanisms driving activity at extremely tiny dimensions. Beyond funding, NSF has been a prime force helping coordinate U.S. nanotechnology policy. These efforts have led to the nation holding the top spot in the field worldwide. Nanotechnology research is leading to advances in drug development, protective gear for soldiers and first responders, computing and communications, imaging, antibiotic resistance and wearable technologies.

MAKING MOLECULAR MOVIES

Using a high-powered X-ray laser and specially designed crystals, NSF-funded researchers have made the first "movie" of photosynthesis, the life-giving process that converts sunlight into chemical energy. A better understanding of how this process occurs could provide new insights to engineer clean, inexpensive, scalable, renewable energy alternatives.

Supported by an NSF award to the Center for Biology with X-Ray Free Electron Lasers, the researchers also create "movies" of high-speed molecular movements that determine how medicines affect diseased cells. The movies are a powerful new tool to capture biological reactions since protein movements occur on a scale far too small and too fast for conventional microscopes to image.





CLOSING IN ON QUANTUM COMPUTING

Google, Microsoft and IBM are working to revolutionize computing by developing a viable quantum computer, an endeavor that will require the development of new materials. NSF-funded researchers are laying the groundwork for quantum technologies by developing new materials and components. This work includes: producing a new material called chromium germanium telluride, which offers advantages over graphene by extending memory and storage; mixing bismuth and nickel to conduct electrical signals at nearly the speed of light, a quantum computing requirement; and operating 2-D materials at room temperature.

Computers based on these materials could advance multiple fields including artificial intelligence, personalized drug development and weather forecasting.

DID YOU KNOW? A team led by NSF-funded computer scientists at the University of California, San Diego, identified the code some carmakers used to circumvent U.S. diesel emissions tests. The deception mechanism allowed some cars to emit 40 times the allowable level of pollutants.

PREPARING TOMORROW'S SCIENTISTS AND ENGINEERS

To prepare students for a world increasingly dependent on technology, educators are developing education and training programs to pique scientific curiosity and strengthen analytical skills.

STUDENTS MONITOR LOCAL POLLUTION

Municipalities spend millions of dollars annually reducing the effects of stormwater runoff. An NSF-funded EPSCoR at the University of Maine is helping decrease these costs. The Stormwater Management Research Team (SMART) program trains high school and college students in water sampling techniques and connects their learning to classroom math and science courses. Students monitor runoff in their communities alongside local water and engineering professionals. Since 2014, over 75 percent of the participating students self-identify as either female or racial minority, and 41 percent of those eligible are enrolled in a STEM degree program. With additional funding from an NSF INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science) grant, the team in Maine formed the SMART INCLUDES Collaborative with eight other states aimed at K-12 underrepresented minorities.

HONING SKILLS FOR 21ST CENTURY SCIENTISTS

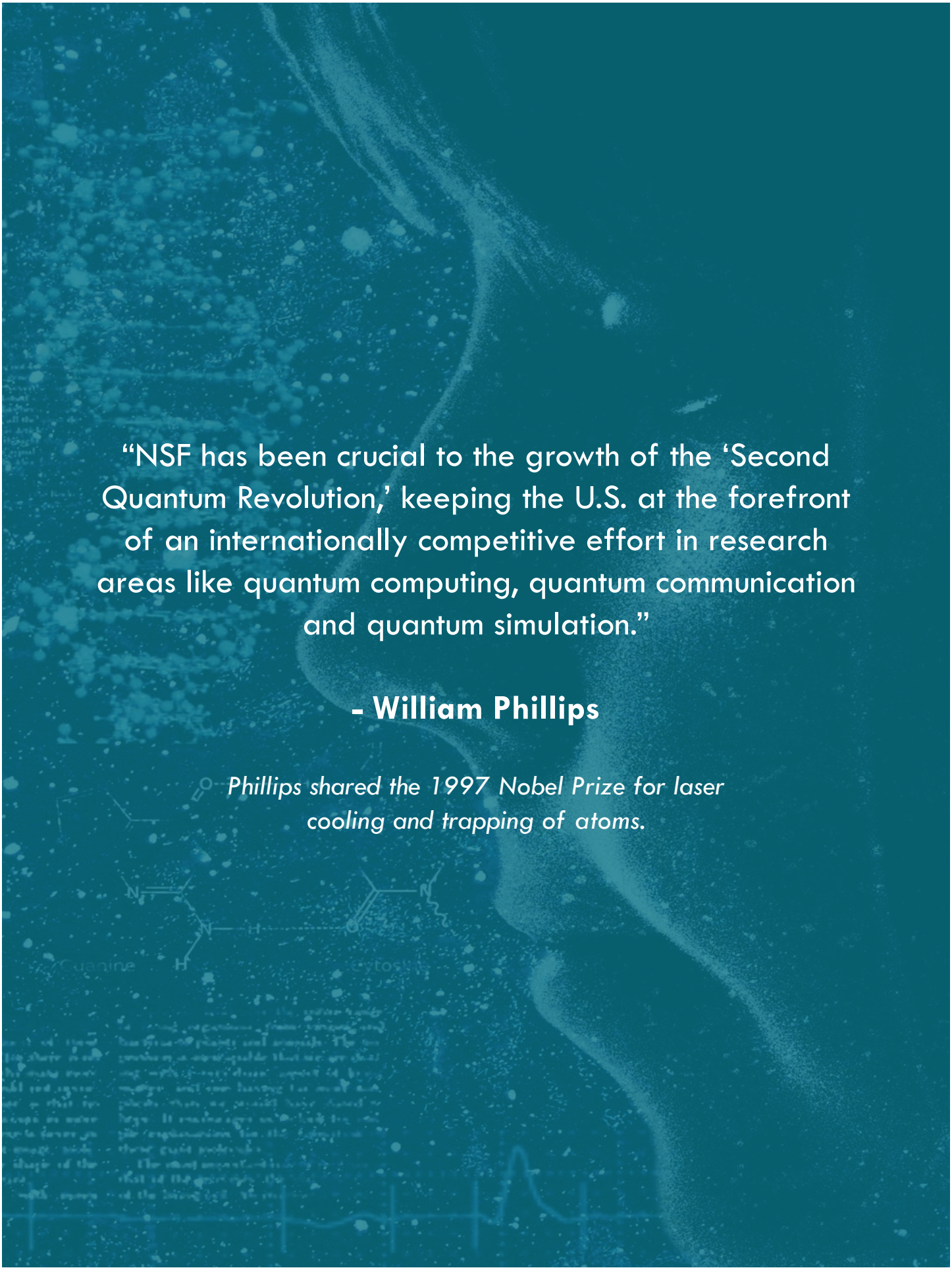
The U.S. and Japan are world leaders in high-frequency terahertz research and nanotechnology. Through the NanoJapan partnership, researchers in the two countries sponsor S&E undergraduates in their labs, helping them gain both research and communication skills essential for leadership in the 21st century STEM workforce. More than 90 percent of NanoJapan alumni pursue advanced STEM degree programs or jobs in the STEM workforce. The National Academy of Engineering and the Institute of International Education recognized the program as a model for expanding international opportunities for STEM students. NanoJapan's success enabled its organizers to attract new funding before NSF support ended, ensuring that the program continues connecting students with world-class research opportunities. It is now called Nakatani Research & International Experiences for Students.

'THINK (AND DO) TANK' FOR STEM EDUCATION

The 21st Century Partnership for STEM Education (21PSTEM) is a 10-year-old nonprofit research and action organization that grew out of the NSF-funded Math and Science Partnership of Greater Philadelphia (MSPGP). The MSPGP brought together 45 Philadelphia area school districts and 13 colleges and universities to improve secondary math and science education in the greater Philadelphia region between 2003 and 2012. Building on the MSPGP's work, 21PSTEM explores new STEM frontiers to fundamentally transform education.

One 21PSTEM project featured a large-scale, randomized-controlled trial to test the use of cognitive science to improve existing science curriculum materials. 21PSTEM also studied teacher assignment instability in K-12 schools across seven states and systemic change in STEM education at six universities over a five-year period.

DID YOU KNOW? More than 2,500 schools offered Computer Science Principles (CSP), the newest Advanced Placement® (AP) computing course, from 2016-17 and 50,000+ students took the AP CSP exam in the spring. NSF supported the development of an instructional framework and exam focused on creative problem-solving and real-world applications of computer science.



"NSF has been crucial to the growth of the 'Second Quantum Revolution,' keeping the U.S. at the forefront of an internationally competitive effort in research areas like quantum computing, quantum communication and quantum simulation."

- William Phillips

Phillips shared the 1997 Nobel Prize for laser cooling and trapping of atoms.

INDIVIDUAL AND SOCIETAL WELL-BEING

"to advance the national health…welfare"

While NSF does not directly fund medical research, many projects in the NSF portfolio produce critical insights that enhance the quality of life for all Americans. The following examples highlight advances to improve brain research, add more precision to disease diagnostics and make medical imaging more patient friendly.

The work stretches beyond the clinic to advanced assistive technologies and rehabilitation techniques for paralysis patients, stroke survivors and children with motor disabilities. NSF-funded research also reaches vulnerable populations through technologies and efforts that ensure access to high-quality medical care in rural areas; manage the devastating effects of the opioid crisis; and reduce childhood injuries.

In "Science: The Endless Frontier," Vannevar Bush wrote, "Discoveries pertinent to medical progress have often come from remote and unexpected sources." NSF will continue to support the men and women whose curiosity compels them to seek answers to the improbable. Their efforts make people's lives better.

BIOMEDICAL FRONTIERS AND TOOLS

From mathematics to geosciences, NSF-supported research often plays a pivotal role in critical advances that improve how we diagnose and treat diseases, maintain health and advance frontier areas in medical research.

A SWAB TO SCREEN FOR CANCER

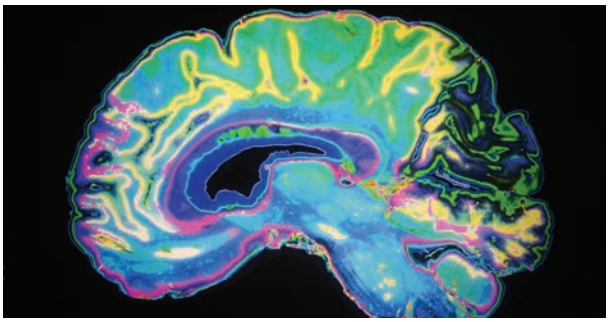
Lung cancer is the leading cancer killer in the U.S., in part because symptoms don't appear until the disease has spread. Evidence suggests that cancer in one part of the body can cause non-cancerous changes in distant organs that, though microscopic, are detectable. With support from NSF, researchers honed a technology — partial-wave spectroscopic microscopy — to detect non-cancerous, nanoscale-sized changes that are telltale signs of lung, colon and pancreatic cancers.

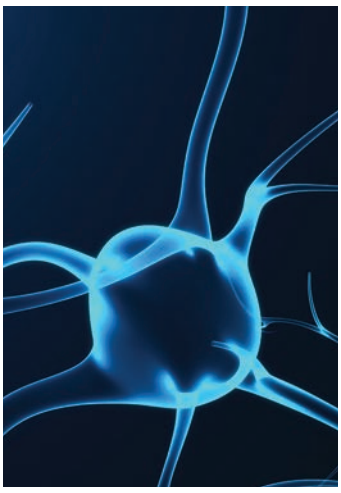
The researchers founded Preora Diagnostics and NanoCytomics to develop their system for use in primary care physician offices. In a lung cancer screening process, the companies successfully differentiated hundreds of patients with and without lung cancer by scanning cells gathered from cheek swabs.

PATIENT-FRIENDLY MRI SCANS

In 2017, the U.S. Food and Drug Administration (FDA) approved two new magnetic resonance imaging (MRI) devices that scan between eight and 16 times faster than conventional methods. Cardiac scans now take just 25 seconds and do not require patients to hold their breath. The FDA approval makes MRIs available to patient populations previously ineligible for some scans, such as those with irregular heartbeats, those with dementia and children.

The devices, now commercially available from Siemens (CS Cardiac Cine) and General Electric (HyperSense), rely on compressed sensing, a breakthrough technique developed 10 years ago by NSF-supported mathematicians. Faster MRI scans will give more patients access to the imaging technology at a lower cost per patient.





CITIZEN SCIENTISTS RECONSTRUCT NEURONS

An online game, "Mozak," that relies on citizen scientists to create 3-D reconstructions of brain cells is accelerating neuroscience research and understanding of neurogenerative diseases like Alzheimer's. Created by NSF-funded researchers, the game led to a four-fold increase in the number of full neuron reconstructions completed over six months. Players generate reconstructions that are 70-90 percent complete, outperforming even the most powerful computers, whose reconstructions range from 10-20 percent complete.

The citizen scientists improved the accuracy of expert-generated, "gold standard" reconstructions, and the reconstruction rate led neuroscientists at the Allen Institute for Brain Science to switch from their state-of-the-art tools to Mozak to speed their work. In 2008, Mozak's creators launched a biochemistry game that solved a decades-long AIDS enzyme puzzle in three weeks.

DID YOU KNOW? NSF's National High Magnetic Field Laboratory advances magnet-related technologies, generates more than $180 million in economic output, and provides more than 1560 jobs. These numbers are expected to increase to $3.6 billion and 31,000 in the next 20 years.

ASSISTING PEOPLE WITH DIVERSE ABILITIES

Technologies based on NSF-funded research are increasing the opportunities available to those with disabilities. From simple actions such as communicating and self-care to attending school or going to work, these advances change lives.

RE-LEARNING TO WALK

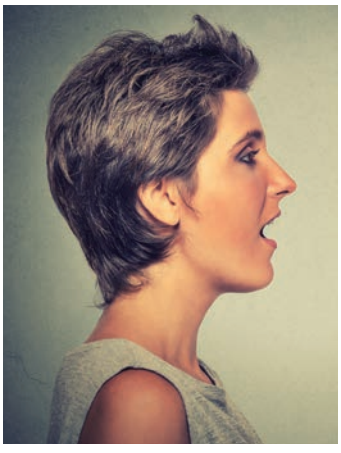
Robotic exoskeletons, fitted with a suite of sensors and robotic controls, are helping stroke survivors retrain their limbs. The technology originated from NSF-funded researchers who developed machines to imitate human muscle. The investigators launched startup Ekso Bionics, receiving seven additional NSF grants to develop the technology.

In 2016, the company's exoskeleton became the first cleared by the FDA specifically for use with stroke patients. Now, as part of an NSF-funded public-private partnership, Ekso Bionics is working with the University of California, Berkeley, General Motors Corporation and the U.S. Postal Service to develop exoskeletons that help workers lift heavy loads safely. Ekso Bionics is a public company listed on the NASDAQ.

HELP FOR CHILDREN WITH MOTOR DISABILITIES

An NSF-funded developmental scientist launched the GoBabyGo! project, which designs and builds tools to assist children with moderate to severe mobility impairments. Studies showed that with the help of a robot, harness or motorized car in a social setting, children improve their social, cognitive and motor skills. GoBabyGo! also teaches caregivers and teams of volunteers how to use available items from a hardware store to build harness systems and retrofit electric toy cars that allow children to move around on their own.

The team is working with a medical equipment manufacturer, a toy company, parents, schools and medical professionals to expand their efforts and reach more children.



PROSTHETIC VOICES

More than 2 million people in the U.S. and 10 million people around the world cannot speak or have a severe speech impairment. An NSF-funded researcher developed a new model that creates a personalized voice by extracting identity information from recipient vocalizations and blending it with speech clarity information from a donor.

The voice-blending technology is the core technology for startup VocaliD, launched with NSF SBIR support. The company custom-designs voices that align with a recipient's gender, age and ethnicity. The diverse voices of healthy donors are drawn from the company's Human Voicebank, a crowdsourcing global platform that has captured millions of sentences from more than 20,000 healthy speaking donors in 110 countries. Unique voices are possible for any device that turns text to speech.

DID YOU KNOW? Jeffrey Hall, Michael Rosbash and Michael Young, the recipients of the 2017 Nobel Prize in physiology or medicine, each received NSF funding during their careers, including grants from OISE, the BIO Directorate and OIA.

STRONG COMMUNITIES

NSF-supported research fortifies the nation's big cities and small towns through improved safety technologies, access to innovative healthcare technologies and options to address the most pressing social issues.

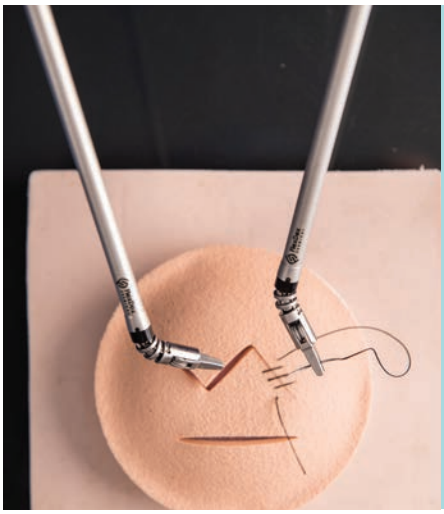
REDUCING CHILD AND TEEN TRAFFIC INJURIES

Each year, over 1.5 million children are involved in motor vehicle crashes and nearly 1,200 are killed. Another 170,000 experience non-fatal injuries. To reduce these numbers, the NSF-supported Center for Child Injury Prevention Studies (CChIPS) conducts research on child safety restraints and technologies aimed at improving teen driving.

Some of this work resulted in revised child passenger safety best practice recommendations from the American Academy of Pediatrics in 2011. Other research resulted in parent/caregiver education and legislative interventions that increased child restraint use from 15 percent to 63 percent between 1999 and 2007 for children ages 4 to 8 years old.

TACKLING ADDICTION

Reversing the U.S. opioid crisis and other addictive behaviors requires innovative solutions. Several NSF-funded small businesses are developing technologies to personalize addiction care, monitoring and treatment. Workit Health, for example, delivers on-the-spot care and monitoring through an online platform and is designing an addiction "thrive-meter" that will help individuals achieve their health goals. Another startup, Mentor on the Go, is improving diagnosis, monitoring and treatment of substance abuse by connecting biosensors to mobile apps to identify someone at risk of substance abuse. And Sober Grid, a social networking app, connects a person trying to stay sober with members of a support system 24-7. NSF-funded researchers are also developing models to study and mitigate the national opioid and heroin co-epidemic.

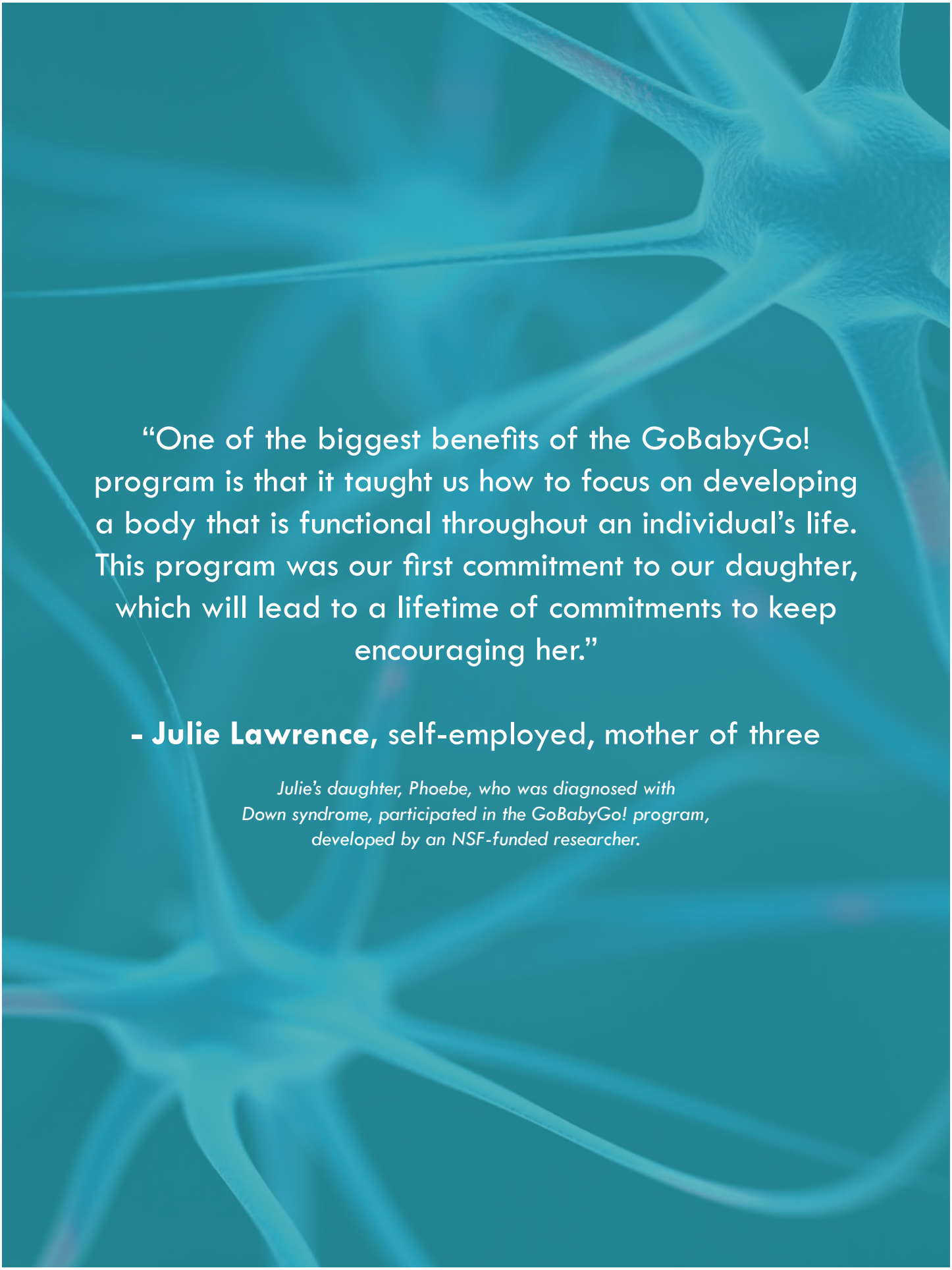


LOW-COST TOOLS FOR RURAL HOSPITALS

A handheld surgical instrument developed by NSF-funded researchers provides remote hospitals the same level of accuracy and high performance as a robotic system, at a fraction of the cost. In use across the U.S., including at Michigan's Cadillac Hospital, recognized as one of the "100 Top Rural & Community Hospitals" in the nation, the instrument relies on parallel kinematics — the study of how different components in a mechanical system move in relation to one another and how multiple chains of motion influence the performance of the system overall.

To commercialize the instrument, the team launched FlexDex Surgical after participating in NSF's I-Corps program, which immerses scientists and engineers in entrepreneurial training.

DID YOU KNOW? Some 144 U.S. military veterans are currently NSF Graduate Research Fellows. Several conduct research related to their service, including next-generation prosthetics and post-traumatic stress disorder. On average, eight GRFs defer their awards each year to engage in active duty military service.



"One of the biggest benefits of the GoBabyGo! program is that it taught us how to focus on developing a body that is functional throughout an individual's life. This program was our first commitment to our daughter, which will lead to a lifetime of commitments to keep encouraging her."

- Julie Lawrence, self-employed, mother of three

Julie's daughter, Phoebe, who was diagnosed with Down syndrome, participated in the GoBabyGo! program, developed by an NSF-funded researcher.

10 BIG IDEAS

Cutting-edge scientific research depends on forward-thinking ideas and long-term investment. For the nation to remain a global research and innovation leader, NSF must continue to identify and invest in novel ideas, tools and approaches in all fields of S&E, as well as inclusive educational pathways. To chart these new directions, NSF developed a set of "10 Big Ideas for Future NSF Investments" – a collection of bold research and process ideas that identify opportunities for future investment.

PURSUING NEW FRONTIERS

HARNESSING THE DATA REVOLUTION

Every area of scientific inquiry and research over the past decades shares a common element — the generation of data. The vast, diverse volume of data previously collected, coupled with the continuous stream of newly created data, holds the key to scientific discovery and advancement in fields from astronomy to zoology.

NSF will continue to support fundamental research in data-driven science and in devices and systems for sensing and communications; shape a cohesive, national-scale approach to research data infrastructure; and develop a 21st century data-capable workforce. Recent grants through the Transdisciplinary Research in Principles of Data Science program, for example, are bringing together statisticians, mathematicians and computer scientists to develop better data mining and machine learning approaches and enhanced visualization techniques.

THE FUTURE OF WORK AT THE HUMAN-TECHNOLOGY FRONTIER

From cognitive assistants that help doctors diagnose disease to automation on the assembly line, people interact with technology in nearly every aspect of daily life. This effort will expand research to understand and build human-technology partnerships; to design and develop new technologies that augment human performance; to illuminate the emerging socio-technological landscape; and to foster lifelong learning with technology.

This focus on the interaction of humans, society and technologies, such as smart systems and artificial intelligence, will help shape the future of work by increasing opportunities for workers, boosting their productivity and strengthening the U.S. economy.

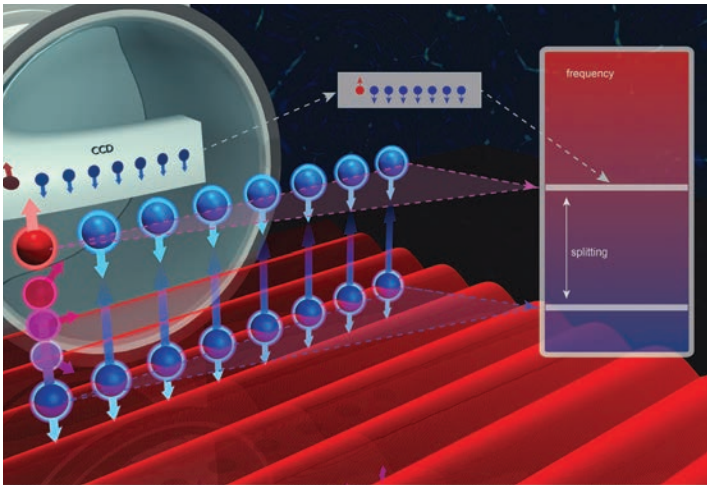
WINDOWS ON THE UNIVERSE: THE ERA OF MULTI-MESSENGER ASTROPHYSICS

Some of the most profound questions in scientific research try to discern the structure and formation of the universe and all matter known within it. For the first time, technological advances allow the simultaneous detection of electromagnetic radiation such as light, particles such as neutrinos, and gravitational waves. This capability will yield new insights into the violent formation and merger of neutron stars and black holes, as well as the synthesis of chemical elements.

NSF plans continued support for major facilities and instrumentation in each area of multi-messenger astrophysics, including electro-magnetic waves, high-energy cosmic particles and astronomical observatories.

THE QUANTUM LEAP: LEADING THE NEXT QUANTUM REVOLUTION

The fundamental qualities of particles and energy at the smallest scale, known as quantum mechanics, were refined less than 100 years ago. Exploiting quantum behavior will lead to the development of new technologies that far surpass today's supercomputers.



For full-scale implementation of quantum computing, communications and sensing, fundamental research is needed, from the design of new quantum materials to the systems and algorithms that will manipulate and control quantum devices. Such endeavors will need convergent breakthroughs, drawing on physics, chemistry, materials, mathematics, engineering, and computing; and leverage industry collaboration. One such effort, NSF's Advancing Communication Quantum Information Research in Engineering (ACQUIRE) program, is a multi-directorate activity supporting research that will lead to scalable, efficient and secure quantum communication systems.

UNDERSTANDING THE RULES OF LIFE: PREDICTING PHENOTYPE

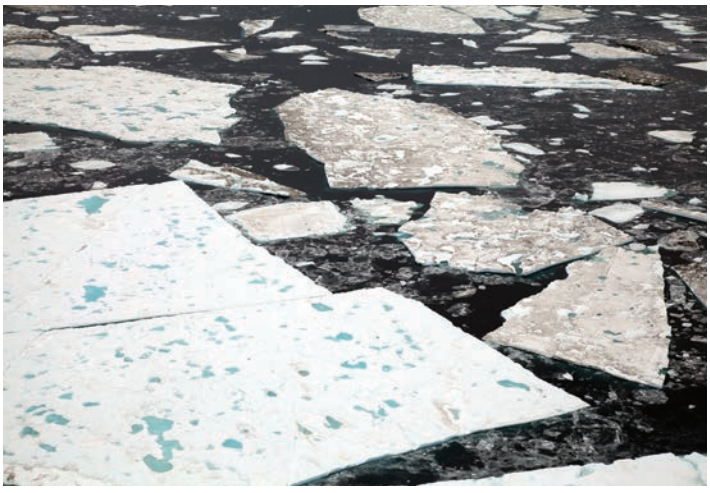
Genes and the environment interact in ways that can modify traits, physiological processes and behaviors of organisms. These experiences can in turn modify the genome. There exists a remarkable amount of complexity in the interactions within and between cells, organisms, individuals, ecosystems and society.

A better fundamental understanding of the "rules" that govern these interactions and outcomes has the potential to be transformative in science, engineering and medicine. Rules of Life projects will provide insights into

how life functions, develop research and infrastructure to explore more complex questions, train the next generation of researchers to approach scientific inquiry across different scales and disciplines, and foster collaboration and convergent research.

NAVIGATING THE NEW ARCTIC

The Arctic is warming at an accelerating rate and faster than the rest of the globe. Melting sea ice, thawing permafrost and other ecosystem changes will present new challenges for the survival and welfare of Arctic communities. At the same time, these changes will bring unprecedented access to living and mineral resources previously hidden under the ice. Reliable



understanding and prediction of Arctic changes and their global linkages are needed to inform decision-making that impacts and supports the nation's social, environmental, economic, infrastructure and security interests, as well as to ensure Arctic infrastructure is sustainable and resilient.

In support of this goal, NSF will build on its leadership in supporting Arctic science and observations, and leverage its support of fundamental geoscience, engineering, computing, biological and social, behavioral and economics research. This will also entail engagement of partners, including Arctic residents and indigenous peoples.

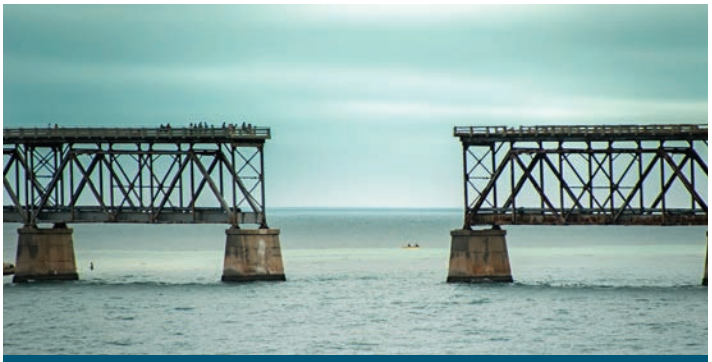
FRAMEWORKS FOR SUCCESS

Growing Convergence Research at NSF seeks to highlight the value of convergence as a process for catalyzing new research directions and advancing scientific discovery and innovation.

The goal of **NSF 2026: Seeding Innovation** is to ensure continuous exploration and risk-taking in S&E by investing in bold, foundational research questions that are large in scope, innovative in character, originate outside of any particular NSF directorate, and require a long-term commitment.

Tools are critical to advancing research and **Mid-scale Research Infrastructure** will provide the necessary infrastructure for S&E projects that fall in the gap between small and large projects funded through other NSF funding mechanisms.

R&D is also stronger when it is inclusive, which is why **NSF INCLUDES** will work to broaden the participation of underrepresented groups in STEM to better reflect the makeup of U.S. society.

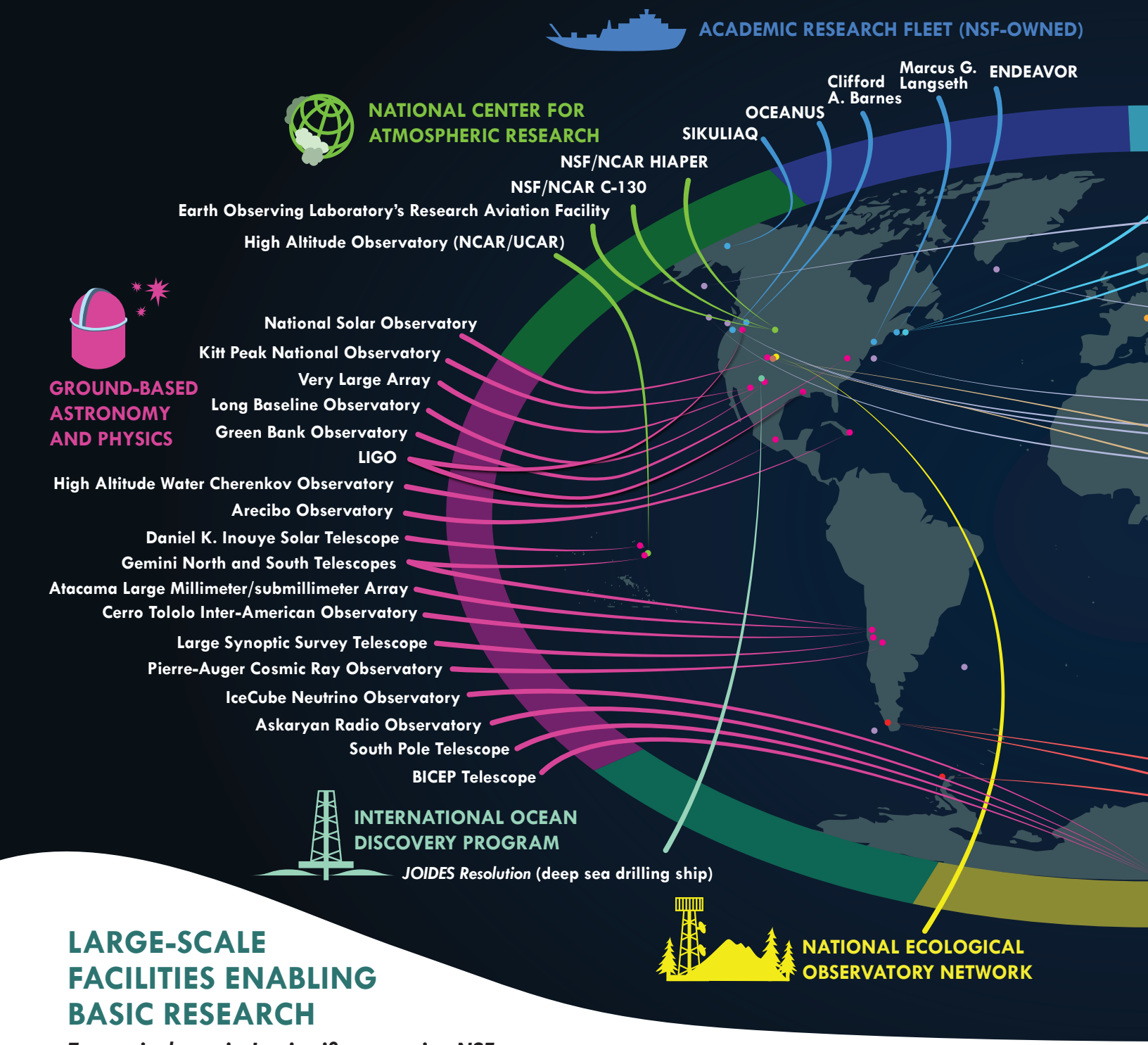


MID-SCALE RESEARCH INFRASTRUCTURE

GROWING CONVERGENCE RESEARCH AT NSF

NSF 2026: SEEDING INNOVATION

NSF INCLUDES: ENHANCING STEM THROUGH DIVERSITY AND INCLUSION



LARGE-SCALE FACILITIES ENABLING BASIC RESEARCH

To sustain the nation's scientific enterprise, NSF supports a wide array of research infrastructure throughout the country and around the world, from polar research stations and telescopes to a fleet of research vessels. These include:

ACADEMIC RESEARCH FLEET (NSF-OWNED)

NSF, in partnership with other federal agencies, supports a robust fleet of 18 academic research vessels that serve as floating laboratories, including the NSF-owned vessels featured on the map.

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH (NCAR)

NCAR is an R&D center devoted to understanding and transferring knowledge about the behavior of the atmosphere and related Earth and geospace systems.

GROUND-BASED ASTRONOMY AND PHYSICS

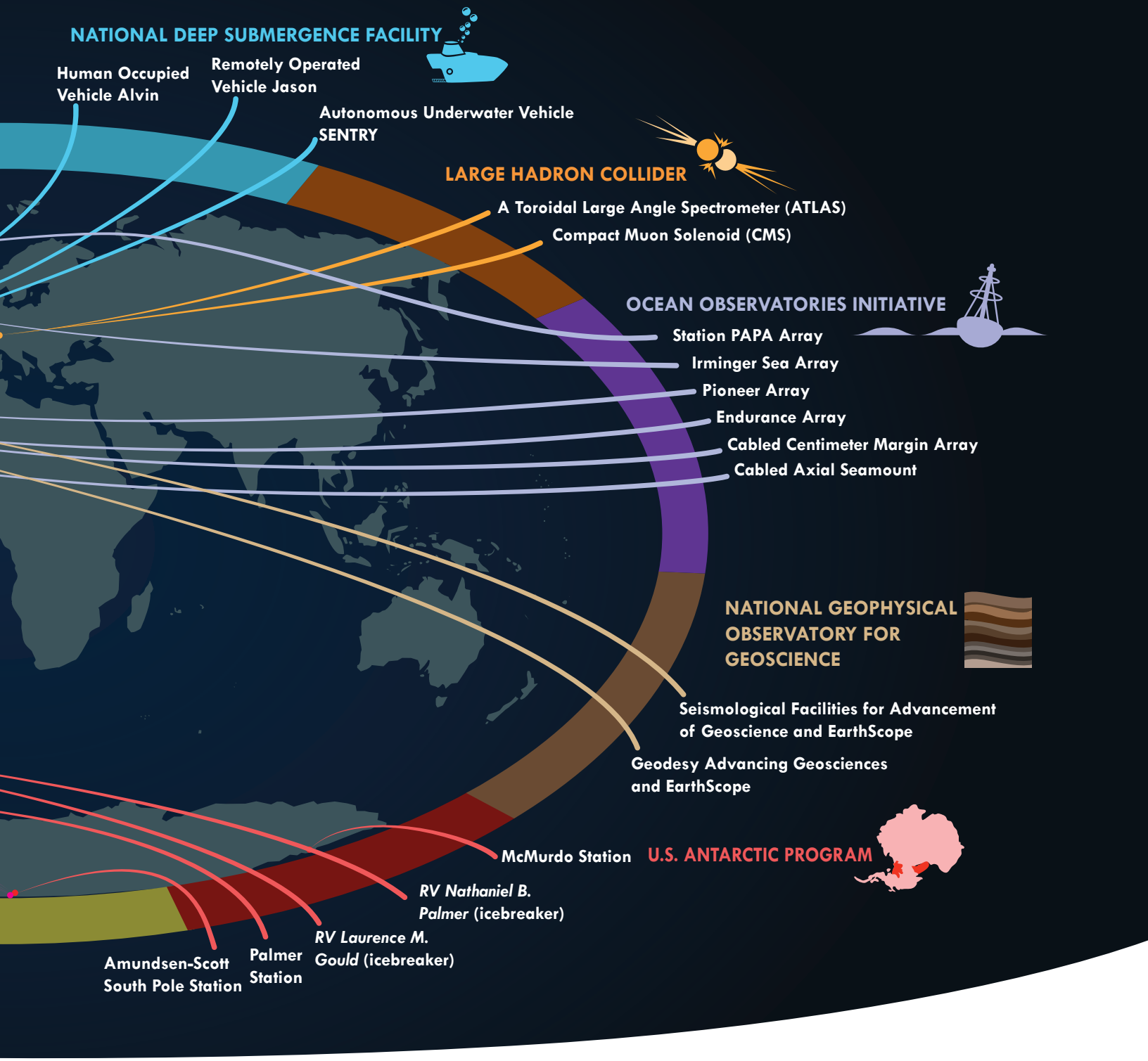
NSF funds a suite of ground-based telescopes and observatories that use cutting-edge technology to explore the universe and advance astronomical research. Many of the world's most renowned telescopes are funded by NSF.

INTERNATIONAL OCEAN DISCOVERY PROGRAM (IODP)

The *JOIDES Resolution*, an ocean-drilling research vessel that is part of IODP, conducts sea drilling to study Earth's oceans and paleoclimate and maintains a number of ocean drill sites around the world.

NATIONAL ECOLOGICAL OBSERVATORY NETWORK (NEON)

NEON is a continental-scale ecological observatory that enables fundamental research on biological responses to



shifting environmental conditions, land-use changes and invasive species.

NATIONAL DEEP SUBMERGENCE FACILITY

With funding from NSF, the Woods Hole Oceanographic Institute operates three deep-sea exploration vehicles: one manned vehicle, one remote-controlled vehicle and one fully autonomous vehicle.

LARGE HADRON COLLIDER (LHC)

NSF supports two particle physics detectors — ATLAS and CMS — at the LHC in Switzerland, the world's largest, most powerful particle accelerator.

OCEAN OBSERVATORIES INITIATIVE (OOI)

NSF has installed a network of instruments, undersea cables and instrumented moorings that spans the Western Hemisphere and measures physical, chemical, geological and biological phenomena in key coastal, regional and global areas.

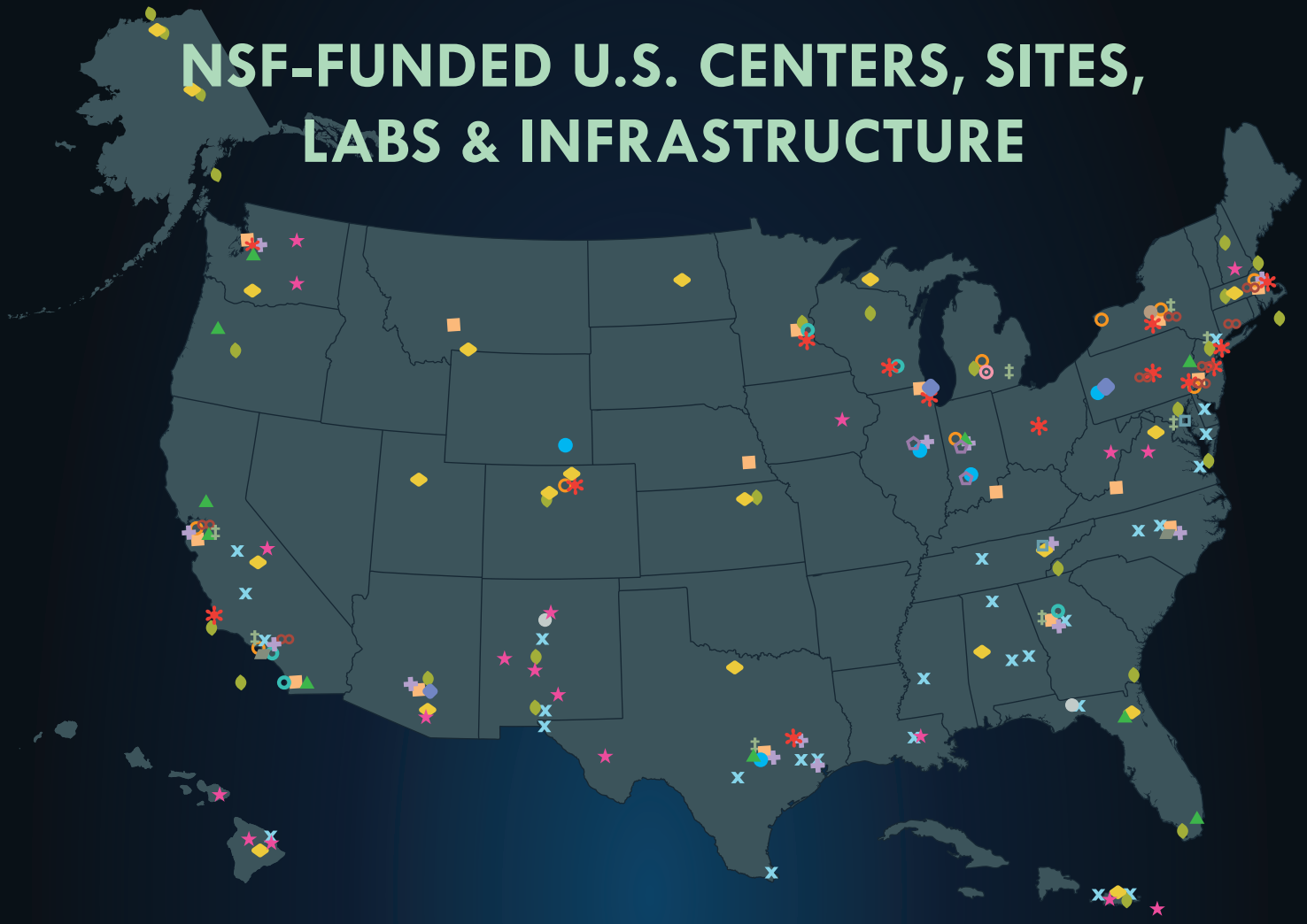
SAGE AND GAGE

Through SAGE and GAGE, NSF funds a suite of community-governed, multi-user facilities that seek to transform understanding of Earth's systems and hazards.

U.S. ANTARCTIC PROGRAM (USAP)

Through USAP, NSF manages all U.S.-related logistics in Antarctica for scientific research, including deep-space exploration, particle physics, Earth's atmospheric chemistry and more.

NSF-FUNDED U.S. CENTERS, SITES, LABS & INFRASTRUCTURE



- CENTERS FOR CHEMICAL INNOVATION
- CENTERS FOR ENVIRONMENTAL IMPLICATIONS OF NANOTECHNOLOGY
- CENTERS OF RESEARCH EXCELLENCE IN SCIENCE AND TECHNOLOGY
- CORNELL HIGH ENERGY SYNCHROTRON SOURCE
- DECISION MAKING UNDER UNCERTAINTY CENTERS
- ENGINEERING RESEARCH CENTERS
- EXPEDITIONS IN COMPUTING
- GROUND-BASED ASTRONOMY AND PHYSICS
- HIGH PERFORMANCE COMPUTING RESOURCES (HPC)
- INNOVATION CORPS NODES (I-CORPS)
- LONG-TERM ECOLOGICAL RESEARCH SITES
- MATERIALS RESEARCH SCIENCE AND ENGINEERING CENTERS
- NATIONAL ECOLOGICAL OBSERVATORY NETWORK
- NATIONAL HIGH-MAGNETIC FIELD LABORATORY
- NATIONAL NANOTECHNOLOGY COORDINATED INFRASTRUCTURE
- NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY
- NATURAL HAZARDS ENGINEERING RESEARCH INFRASTRUCTURE
- NETWORK FOR COMPUTATIONAL NANOTECHNOLOGY
- SCIENCE AND TECHNOLOGY CENTERS
- SYNTHESIS CENTERS

BIOLOGICAL FIELD STATIONS AND MARINE LABORATORIES (FSML)

FSMLs are off-campus facilities for research and education conducted in terrestrial, freshwater and marine ecosystems. NSF supports more than 180 sites across the U.S. and world. (Sites not shown on map.)

CENTERS FOR CHEMICAL INNOVATION (CCI)

CCIs focus on solving major, long-term fundamental chemical research challenges and partner with industry, government laboratories and international organizations.

- CCI Solar Fuels (CA)
- Center for Aerosol Impacts on Climate and the Environment (CA)
- Center for Chemical Evolution (GA)
- Center for Chemistry at the Space-Time Limit (CA)
- Center for Sustainable Nanotechnology (WI)
- Center for Sustainable Polymers (MN)
- NSF Center for Selective C-H Functionalization (GA)

CENTERS FOR ENVIRONMENTAL IMPLICATIONS OF NANOTECHNOLOGY (CEIN)

CEINs conduct fundamental research and education on the implications of nanotechnology for the environment and living systems and address their interactions with nanoparticles and nanostructured materials, devices and systems.

- Center for the Environmental Implications of NanoTechnology (NC)
- University of California Center for Environmental Implications of Nanotechnology (CA)

CENTERS OF RESEARCH EXCELLENCE IN SCIENCE AND TECHNOLOGY (CREST)

These centers enhance the research capabilities of minority-serving institutions by developing new knowledge, strengthening faculty research productivity and expanding the presence of students historically underrepresented in STEM disciplines.

- Advanced Center for Laser Science and Spectroscopy (VA)
- Bioenergy Center (NC)
- Center for Advanced Functional Materials (CA)
- Center for Cellular and Biomolecular Machines (CA)
- Center for Climate Change and Carbon Sequestration (CA)
- Center for Complex Materials Design for Multidimensional Additive Processing (FL)
- Center for Energy and Environmental Sustainability (TX)
- Center for Energy and Sustainability (CA)
- Center for Environmental Neuroscience (Puerto Rico)
- Center of Excellence in Nanobiomaterials derived from Biorenewable and Waste Resources (AL)
- Center for Forest Ecosystems Assessment (AL)
- Center for Functional Nanoscale Materials (GA)
- Center for Gravitational Wave Astronomy (TX)
- Center for Interface Design and Engineered Assembly of Low-Dimensional Systems (NY)
- Center for the Integrated Study of Coastal Ecosystem Processes and Dynamics (MD)
- Center for Nano & Bio-inspired Materials and Devices (VA)
- Center for NanoBiotechnology Research (AL)
- Center for Next Generation Multifunctional Composites (LA)
- Center for Physics and Chemistry Materials (TN)
- Center for Research and Education in Optical Sciences and Applications (DE)
- Center for Research on Complex Networks (TX)
- Center for the Sharing of Cyber-Resource to Advance Science and Education (TX)
- Center in Tropical Ecology and Evolution in Marine and Terrestrial Environments (HI)
- Center for Security and Privacy Enhanced Cloud Computing (TX)
- Center for Water and the Environment (NM)
- Computational Center for Fundamental and Applied Science and Education (NC)
- Interdisciplinary Center for Nanotoxicity (MS)
- Interdisciplinary Center of Research Excellence in Design of Intelligent Technologies for Smartgrids (NM)
- Nanotechnology Center for Biomedical, Environmental and Sustainability Applications (Puerto Rico)

CORNELL HIGH ENERGY SYNCHROTRON SOURCE

This NSF-funded, state-of-the-art synchrotron radiation facility supports research in physics, chemistry, biology and environmental and materials science. (NY)

DECISION MAKING UNDER UNCERTAINTY CENTERS (DMUU)

DMUUs are centers that support research to advance a better understanding of decision making amid long-term environmental risks associated with a changing climate.

- Center for Climate and Energy Decision Making (PA)
- Center for Robust Decision Making on Climate and Energy Policy (IL)
- Decision Center for a Desert City (AZ)

ENGINEERING RESEARCH CENTERS (ERC)

ERCs help the U.S. meet its engineering challenges and prepare the future engineering workforce.

- Center for Advanced Self-Powered Systems of Integrated Sensors and Technologies (NC)
- Center for Bio-mediated and Bio-inspired Geotechnics (AZ)
- Center for Cell Manufacturing Technologies (GA)
- Center for Cellular Metamaterials (MA)
- Center for Innovative and Strategic Transformation of Alkane Resources (IN)
- Center for Nanomanufacturing Systems for Mobile Computing and Energy Technologies (TX)
- Center for Nanotechnology Enabled Water Treatment Systems (TX)
- Center for Power Optimization for Electro-Thermal Systems (IL)
- Center for Precise Advanced Technologies and Health Systems for Underserved Populations (TX)
- Center for Quantum Energy and Sustainable Solar Technologies (AZ)
- Center for Re-Inventing the Nation's Urban Water Infrastructure (CA)
- Center for Sensorimotor Neural Engineering (WA)
- Center for Translational Applications of Nanoscale Multiferroic Systems (CA)
- Center for Ultra-wide-area Resilient Electric Energy Transmission Networks (TN)

EXPEDITIONS IN COMPUTING

The Expeditions in Computing program is a center-scale investment in ambitious

research that promises to define the future of computing and information science.

- An Expedition in Computing for Compiling Printable Programmable Machines (MA)
- CompSustNet: Expanding the Horizons of Computational Sustainability (NY)
- Evolvable Living Computing - Understanding and Quantifying Synthetic Biological Systems' Applicability, Performance, and Limits (MA)
- Expeditions in Computer Augmented Program Engineering (ExCAPE): Harnessing Synthesis for Software Design (PA)
- Expeditions in Computing: The Science of Deep Specification (NJ)
- Making Sense at Scale with Algorithms, Machines, and People (CA)
- Molecular Programming Architectures, Abstractions, Algorithms, and Applications (CA)
- Socially Assistive Robots (CT)
- Visual Cortex on Silicon (PA)

★ GROUND-BASED ASTRONOMY AND PHYSICS

NSF-supported ground-based telescopes and observatories explore the universe using cutting-edge technology.

- Arecibo Observatory (Puerto Rico)
- Gemini Observatory (HI)
- Green Bank Observatory (WV)
- LIGO (LA/WA)
- Long Baseline Observatory (CA, NM, HI, IA, TX, WA, AZ, NH, Virgin Islands)
- National Optical Astronomy Observatory (AZ)
- National Radio Astronomy Observatory (NM/VA)
- National Solar Observatory (AZ, CA, HI, NM)

● HIGH PERFORMANCE COMPUTING (HPC) RESOURCES

NSF supports HPC resources throughout the U.S. that enable academic and industrial researchers, regardless of discipline or funding agency, to perform advanced analysis and simulations on everything from atoms to the structure of the early universe.

- Blue Waters: National Center for Supercomputing Applications (IL)
- Bridges: Pittsburgh Supercomputing Center (PA)
- Comet: San Diego Supercomputer Center (CA)
- Jetstream: Indiana University Pervasive Technology Institute (IN)
- Stampede2: Texas Advanced Computing Center (TX)
- Wrangler: Texas Advanced Computing Center (TX)
- Yellowstone: NCAR-Wyoming Supercomputing Center (WY)

● INDUSTRY-UNIVERSITY COOPERATIVE RESEARCH CENTERS (IUCRC)

IUCRCs enable faculty and students to investigate fundamental research questions inspired by industry members and other stakeholders. More than 75 IUCRCs with a total of almost 900 unique members operate across the nation. (Centers not shown on the map.)

✚ INNOVATION CORPS NODES (I-CORPS NODES)

These regional hubs provide the research infrastructure and entrepreneurship training to help researchers transition fundamental science and engineering discoveries to the marketplace. They also support more than 80 I-Corps sites across the country and deliver a seven-week I-Corps curriculum to the I-Corps teams.

- Bay Area Node (CA)
- DC Regional Node (MD)
- Midwest Node (MI)
- New York City Regional Node (NY)
- Upstate New York Regional Node (NY)
- South Node (GA)
- Southwest Node (TX)
- Southern California Node (CA)

● LONG-TERM ECOLOGICAL RESEARCH (LTER) SITES

The LTER program supports 28 sites representative of different biomes that allow for the study of ecological phenomena over long periods of time.

- Andrews Forest (OR)
- Arctic (AK)
- Baltimore Ecosystem Study (MD)
- Beaufort Lagoon Ecosystem (AK)
- Bonanza Creek (AK)
- California Current Ecosystem (CA)
- Cedar Creek Ecosystem Science Reserve (MN)
- Central Arizona-Phoenix (AZ)
- Coweeta (GA)
- Florida Coastal Everglades (FL)
- Georgia Coastal Ecosystems (GA)
- Harvard Forest (MA)
- Hubbard Brook (NH)
- Jornada Basin (NM)
- Kellogg Biological Station (MI)
- Konza Prairie (KS)
- LTER Network Communications Office (CA)
- Luquillo (Puerto Rico)
- McMurdo Dry Valleys (Antarctica, not shown on map)
- Moorea Coral Reef (Moorea, not shown on map)
- Niwot Ridge (CO)
- North Temperate Lakes (WI)
- Northeast U.S. Shelf (MA)
- Northern Gulf of Alaska (AK)
- Palmer Antarctica (Antarctica, not shown on map)
- Plum Island Ecosystems (MA)
- Santa Barbara Coastal (CA)
- Sevilleta (NM)
- Virginia Coast Reserve (VA)

✱ MATERIALS RESEARCH SCIENCE AND ENGINEERING CENTERS (MRSEC)

This network of university-based centers supports materials research and education and addresses fundamental problems important to society.

- Bioinspired Soft Materials Center (MA)
- Center for Dynamics and Control of Materials (TX)
- Center for Emergent Materials (OH)
- Chicago Materials Research Science and Engineering Center (IL)
- Cornell Center for Materials Research (NY)
- Harvard Materials Research Science and Engineering Center (MA)
- Illinois Materials Research Center (IL)
- Materials Research Science and Engineering Center at UCSB (CA)
- Materials Research Science and Engineering Center at UPenn (PA)
- Materials Research Science and Engineering Center on Structured Interfaces (WI)
- MIT Materials Research Science and Engineering Center (MA)
- MRSEC: Center for Multifunctional Materials (IL)
- MRSEC: Center for Nanoscale Science (PA)
- MRSEC: Columbia Center for Precision Assembly of Superstratic and Superatomic Solids (NY)
- MRSEC: Polarization and Spin Phenomena in Nanoferroic Structures (P-SPINS) (NE)
- MRSEC: UW Molecular Engineering Materials Center (WA)
- NYU Materials Research Science and Engineering Center (NY)

- Princeton Center for Complex Materials (NJ)
- Soft Materials Research Center (CO)
- UMN Materials Research Science and Engineering Center (MN)

NATIONAL ECOLOGICAL OBSERVATORY NETWORK (NEON)

NEON is a continental-scale network of 20 core sites that enable fundamental research on biological responses to shifting environmental conditions, land-use changes, and invasive species.

- Caribou Creek - Poker Flats Watershed (AK)
- Central Plains Experimental Range (CO)
- Guanica Forest (Puerto Rico)
- Harvard Forest (MA)
- Konza Prairie Biological Station (KS)
- LBJ National Grassland (TX)
- Niwot Ridge Mountain Research Station (CO)
- Oak Ridge (TN)
- Onaqui-Ault (UT)
- Ordway-Swisher Biological Station (FL)
- Pu'u Maka'ala Natural Area Reserve (HI)
- San Joaquin Experimental Range (CA)
- Santa Rita Experimental Range (AZ)
- Smithsonian Conservation Biology Institute (VA)
- Talladega National Forest (AL)
- Toolik (AK)
- UNDERC (MI)
- Wind River Experimental Forest (WA)
- Woodworth (ND)
- Yellowstone Northern Range (WY)

NATIONAL HIGH-MAGNETIC FIELD LABORATORY (NHMFL)

The NHMFL is the largest and highest-powered magnet laboratory in the world. (FL/NM)

NATIONAL NANOTECHNOLOGY COORDINATED INFRASTRUCTURE (NNCI)

These university-based facilities advance nanoscale science, engineering and technology by providing researchers from academia, industry and government access to leading-edge tools and expertise.

- Center for Nanoscale Systems (MA)
- Cornell Nanoscale Science and Technology Facility (NY)
- Kentucky Multi-Scale Manufacturing and Nano Integration Node (KY)
- Mid-Atlantic Nanotechnology Hub (PA)
- Midwest Nanotechnology Infrastructure Corridor (MN/ND)
- Montana Nanotechnology Facility (MT/MN)
- nano@Stanford (CA)
- Nanotechnology Collaborative Infrastructure Southwest (AZ)
- National Center for Earth and Environmental Nanotechnology Infrastructure (VA)
- Nebraska Nanoscale Facility (NE)
- NNCI Coordinating Office (GA)
- Northwest Nanotechnology Infrastructure (WA/OR)
- Research Triangle Nanotechnology Network (NC)
- San Diego Nanotechnology Infrastructure (CA)
- Soft and Hybrid Nanotechnology Experimental Resource (IL)
- Southeastern Nanotechnology Infrastructure Corridor (GA/NC)
- Texas Nanofabrication Facility (TX)

NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY

This nuclear science research facility allows researchers around the world to explore the inner workings of atoms and their role in the universe. (MI)

NATURAL HAZARDS ENGINEERING RESEARCH INFRASTRUCTURE (NHERI)

NHERI provides university-based, experimental facilities with state-of-the-art tools to investigate earthquake, wind and water hazards, and test ground-breaking concepts to protect individuals, communities and critical infrastructure.

- Boundary Layer Wind Tunnel, Wind Load and Dynamic Flow Simulators, and Pressure Loading Actuators (FL)
- Computational Modeling and Simulation Center (CA)
- Cyberinfrastructure (TX)
- Geotechnical Centrifuges (CA)
- Large, High-Performance Outdoor Shake Table (CA)
- Large, Mobile Dynamic Shakers for Field Testing (TX)
- Large-Scale, Multi-Directional, Hybrid Simulation Testing Capabilities (PA)
- Large Wave Flume and Directional Wave Basin (OR)
- Network Coordination (IN)
- Post-Disaster, Rapid Response Research Facility (WA)
- Twelve-Fan Wall of Wind (FL)

NETWORK FOR COMPUTATIONAL NANOTECHNOLOGY (NCN)

This multi-university network develops models and simulation tools to predict biological phenomena and manufacturing processes at the nanoscale and beyond for nanotechnology-based components, devices and systems. NCN also serves as a virtual laboratory through online simulation and education.

- Engineered nanoBIO Node (IN)
- Hierarchical nanoMFG Node (IL)
- nanoHUB (IN)

SCIENCE AND TECHNOLOGY CENTERS (STC)

The program supports innovative, potentially transformative, complex research and education projects that require large-scale, long-term efforts.

- Center for Biology with X-Ray Free Electron Lasers (NY)
- Center for Brains, Minds, and Machines (MA)
- Center for Integrated Quantum Materials (MA)
- BEACON Center for the Study of Evolution in Action (MI)
- Center for Dark Energy Biosphere Investigations (CA)
- Center for Energy Efficient Electronics Science (CA)
- Center for Emergent Behaviors of Integrated Cellular Systems (MA)
- Center for Science of Information (IN)
- Center for Bright Beams (NY)
- Center for Cellular Construction (CA)
- Center for Engineering MechanoBiology (PA)
- Center on Real-Time Functional Imaging (CO)

SYNTHESIS CENTERS

Synthesis centers accelerate scientific understanding in the development of new tools and standards for managing data, new analysis capabilities with broad utility, and foster interdisciplinary collaborations in both educational and professional contexts.

- National Institute for Mathematical and Biological Synthesis (TN)
- National Socio-Environmental Synthesis Center (MD)
- CyVerse (AZ)

RESOURCES AND SOCIAL MEDIA

National Science Foundation	nsf.gov
Directorate for Biological Sciences	nsf.gov/BIO
Directorate for Computer and Information Science and Engineering	nsf.gov/CISE
Directorate for Education and Human Resources	nsf.gov/EHR
Directorate for Engineering	nsf.gov/ENG
Directorate for Geosciences	nsf.gov/GEO
Directorate for Mathematical and Physical Sciences	nsf.gov/MPS
Directorate for Social, Behavioral, and Economic Sciences	nsf.gov/SBE
Office of Integrated Activities	nsf.gov/OIA
Office of International Science and Engineering	nsf.gov/OISE
Established Program to Stimulate Competitive Research	nsf.gov/epscor
NSF and Congress Toolkit	nsf.gov/toolkit
Science360	science360.gov
Social Media	nsf.gov/social

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p. iv: Visualization Interfaces and Applications: Joanna K. Wozniak, Texas Advanced Computing Center, The University of Texas (UT) at Austin; Research Team: Avinash P. Nayak, UT at Austin; Swastibrata Bhattacharyya, Indian Institute of Science; Jie Zhu, UT at Austin; Jin Liu, UT at Austin; Xiang Wu, UT at Austin; Tribhuwan Pandey, Indian Institute of Science; Changqing Jin, Chinese Academy of Sciences; Abhishek K. Singh, Indian Institute of Science; Deji Akinwande, UT at Austin; Jung-Fu Lin, UT at Austin

p. 1: Self Reflected 22K gold micro-etching under multicolored light, 130" x 96", 2014-2016, Dr. Greg Dunn and Dr. Brian Edwards

p. 2: NSF

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